25X1A5a1

Next 2 Page(s) In Document Exempt

TABLE OF CONTENTS

I. INTRODUCTION

The transparency and visibility of the atmosphere at any particular location have considerable effect on the accuracy of position determination, the quality of aerial photography and consequently, on the accuracy of maps compiled from that photography.

Soviet scientists apparently have considered this problem significant 25X1A5a1 enough to warrant considerable investigation. [redacted] 25X1A5a1 [redacted] collected and analyzed Soviet scientific data dealing with this problem. Parts II and III of this report contain his analysis of the quality and significance of Soviet work in this field. Part IV is a bibliographic reference guide to additional data found by the staff of this project in the course of its work on Soviet geodesy, photogrammetry and cartography. No attempt has been made to collect all available Soviet data on these subjects.

II. REPORT NO. 1

on

SOVIET INVESTIGATIONS OF THE TRANSPARENCY OF THE EARTH'S ATMOSPHERE

[redacted] 25X1A5a1

I have gone through all official publications of the Soviet Academy of Sciences available to me, including the Doklady, the Izvestiya (Seriya Geografich. i Geofiz; Seriya Fizicheskaya) and the Astronomicheskiy Zhurnal, for recent years. There have been several important articles on the transmission of light through the atmosphere, and abstracts of the three most significant ones are enclosed.

These investigations are not generally known outside the Soviet Union. At the present time they probably have no direct practical application. But it seems certain that their elucidation of the action of aersols in air will become increasingly valuable as these results are made use of in practical experiments.

Broadly speaking, Soviet research falls into three categories in this field:

1. The theoretical determination of the scattering phase function for large water droplets. The work by Shifrin, with its detailed tables, is by far the best that I have seen (Part A). In practice most aerosols are in the nature of either large water droplets or ice crystals. Shifrin's theory does not apply to the latter. But it should become immediately applicable to problems of scattering in fog, and various kinds of clouds. Fog particles range between 1μ and 120μ in diameter, cloud particles

average between 8μ for stratus to 20μ for nimbostratus. Since the applicability of Shifrin's tables rests upon the condition

$$\frac{2\pi a}{\lambda} \gg 1$$

we conclude that for nearly all these droplets the theory is applicable, if the light is observed in the usual range of $0.3\mu < \lambda < 1\mu$.

The remarkable tendency of the droplets to scatter forward (by a ratio of 168 to 1) should be of enormous importance. Undoubtedly, this same tendency in snow crystals will turn out to be somewhat less pronounced.

2. The experimental determination of the shape of the scattering phase function by aerosols. This aspect of the problem is discussed in the work of Mrs. Pyaskovskaya - Fesenkova (Part B). The results indicate a strongly forward throwing function, but the effect is apparently smaller than computed by Shifrin. Since the observational work was in part carried out at high elevations the aerosols may have been in part snow crystals, rather than drops of water.

3. Studies of the transmission of the atmosphere in the extreme ultraviolet region accessible without rockets ($\lambda >$ 2950A). This topic has been discussed observationally and theoretically by Rodionov (Part C). There appears to be a tendency in the atmosphere to produce what Rodionov calls an anomalous transparency for UV light. Actually, this is not an effect of greater transparency. It is rather an effect of less than the expected increase in absorption at $<$3260A, for increasing air masses. The results do not now have any practical value, but they have led to the discovery of an interesting broad absorption band produced by those aerosols that lie relatively

close to the surface of the earth. Such a band had been predicted previously by Haughton and Stratton, and by others.

In view of the fact that in many modern works on visibility the character of the phase function is ignored (see W.E. Knowles Middleton: Visibility in Meteorology, Second Edition, Toronto, 1947), these Soviet investigations must be regarded as an important advance. They were probably not influenced by the work of van de Hulst in America and Holland (I have found no references to him in the publications I have examined).

It is clear that these Soviet investigations even now open the way to some constructive advances that, presumably, could be of great practical significance. I shall outline only a few of them:

1. Mrs. Fesenkov's method of obtaining a measure of the transparency coefficient p, on a clear day, is the easiest that has as yet been devised, and its accuracy is somewhat higher than that of the customary procedure.

2. Her determination of the phase function for terrestrial aerosols is valuable and should be applied on a large scale in different locations and under different conditions. As yet, there is no clear correlation between the nature of the phase function and the character of the aerosols. For example, it seems to me that a strongly forward-throwing function must be operating in the case of salt particles thrown into the lower atmosphere by the waves at sea, and especially by the surf on a beach. This would result in a large difference between the blueness of the sky near the sun and at the point diametrically opposite to the sun (or as near to that point above the horizon as is reasonable). Thus, if seems to be that this phase function differs drastically from the phase function that operates in a dust storm or that operates in an atmosphere filled with snow crystals.

3. Shifrin's tables, (reproduced here as a section of Part A) are directly applicable toward the solution of radiative transfer problems of the kind investigated by Chandrasekhar and by van de Hulst. No such application has as yet been made. It would apply to an atmosphere filled with fairly large water droplets.

4. The theoretical interpretation of the peculiar transparency of the atmosphere in the region λ 3000 promises to throw further light upon the nature of the aersols. This, too, would require some further studies before any practical results can be expected.

PART A

K. S. Shifrin: Scattering of Light from Large Water Droplets and the Polarization of the Light in Rainbows. (Izvestiya, Akademiya Nauk, Ser. Geograf. i Geofiz.; T. 14, Vyp. 2, pp. 128-163, 1950).

1. Introduction

The effects considered consist of ordinary reflection and refraction in transparent spherical drops of water. Attention is called to serious errors in an earlier paper by V.V. Shuleikin.

When $\lambda/2\pi a = \frac{1}{x} \rightarrow 0$ the formulas of geometrical optics became identical with those of wave theory, except for very angles of $\theta \sim \frac{1}{x}$ from the forward direction where diffraction effects dominate the picture, resulting in a large amount of scattered light (roughly $\sim a^4/\lambda^2$). The amount of this light scattered by diffraction forward is equal to that scattered in all directions, and the total amount scattered is $2\pi a^2$.

2. General Considerations

The equations of Fresnel are used for the coefficients of reflection r and of refraction d. Subscripts p and s distinguish between rays having their electric vectors in the plane of incidence and at right angles to it. Absorption within the drops is neglected and n = 1.33000 is adopted throughout (this corresponds to λ = 0.656μ and t = 20°C).

The incident ray gives rise to an infinite number of resultant rays: the ray reflected from the outer surface is the first resultant rays, that which has been refracted twice is the second, etc. Certain properties of these rays are easily derived.

1. All resultant rays are in the plane of the incident ray. In the case of polarization

$$I_s^o = I^o \sin^2\alpha; \quad I_p^o = I_o \cos^2\alpha.$$

When the incident light is unpolarized

$$I_s^o = I_p^o = \frac{1}{2} I^o .$$

2. All resultant rays of a p ray are also p rays, and all resultant rays of an s ray are s rays.

3. All rays which result from a ray whose angle of incidence is φ, emerge under the same angle φ.

4. The resultant rays emerge from points in the drop having polar angles of θ, $\theta + \mu$, $\theta + 2\mu$, ..., when the incident ray strikes the drop below its central line, $\theta > \pi$; and it makes the angles θ, $\theta - \mu$, $\theta - 2\mu$ ... when $\theta < \pi$. The angle of turn (clockwise when $\theta < \pi$ and counterclockwise when $\theta > \pi$ is given by

$$\beta^{(K)} = (K - 2)\pi + 2 [\varphi - (K - 1)\Psi]$$

where Ψ is the angle of refraction:

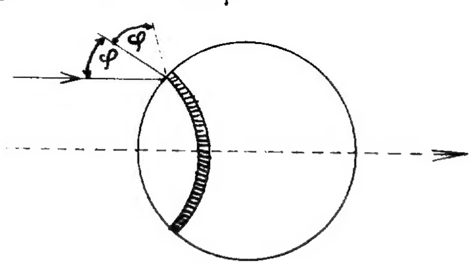
$$\frac{\sin\varphi}{\sin\Psi} = n$$

5. The "width" of each resultant ray is the same as that of the incident ray. Hence

$$I^o = I^{(1)} + I^{(2)} + I^{(3)} + ...$$

3. <u>Reflected Light</u> (I^1)

In this case $\beta^{(1)} = \pi - 2\varphi$



It is easily seen that the phase function

$$S^{(1)}_{s,p} = \frac{a^2}{4} I^o_{s,p}\, r_{s,p} \quad ;$$

when $r = 1$ (totally reflecting sphere) the phase function is spherical in shape

$$S = \frac{a^2}{4} I^o$$

and is therefore independent of φ. But in the case of water $r \neq 1$. In terms of φ and n,

$$r_s = \left(\frac{\sqrt{n^2 - \sin^2\varphi} - \cos\varphi}{\sqrt{n^2 - \sin^2\varphi} + \cos\varphi} \right)^2$$

$$r_p = \left(\frac{\sqrt{n^2 - \sin^2\varphi} - n^2\cos\varphi}{\sqrt{n^2 - \sin^2\varphi} + n^2\cos\varphi} \right)^2$$

From this we get for the phase functions

$$S^{(1)}_s = \frac{a^2}{4} I^o_s \left(\frac{\sqrt{n^2 - \cos^2\frac{\beta^{(1)}}{2}} - \sin\frac{\beta^{(1)}}{2}}{\sqrt{n^2 - \cos^2\frac{\beta^{(1)}}{2}} + \sin\frac{\beta^{(1)}}{2}} \right)$$

$$S^{(1)}_p = \frac{a^2}{4} I^o_p \left(\frac{\sqrt{n^2 - \cos^2\frac{\beta^{(1)}}{2}} - n^2\sin\frac{\beta^{(1)}}{2}}{\sqrt{n^2 - \cos^2\frac{\beta^{(1)}}{2}} + n^2\sin\frac{\beta^{(1)}}{2}} \right)^2$$

4. <u>Light refracted by Droplet</u>

Here

$$\beta^{(2)} = 2\,(\varphi - \psi)$$

This ray can be deflected to a maximum angle of 82.5°. All of this light goes forward, and is contained within a cone with angle 82.5°.

Out of the incident radiation dF^o the amount that will emerge in this

form is $d^2\, dF^o$. At a distance R from the droplet this radiation is spread over a zone of area

$$ds^{(2)} = R^2\, 2\pi \sin \beta^{(2)} d\beta^{(2)}$$

This turns out to be

$$ds^{(2)} = R^2 2\pi \sin \beta^{(2)} 2d\varphi \left(1 - \frac{1}{n}\frac{\cos \varphi}{\cos \psi}\right)$$

The intensity of this light is

$$I^{(2)} = \frac{dF^{(2)}}{ds^{(2)}} = \frac{a^2}{4R^2} I^{(o)} \frac{d^2 \sin 2\varphi}{\sin \beta^{(2)} \left[1 - \frac{1}{n}\frac{\cos \varphi}{\cos \psi}\right]}$$

We again obtain $S^{(2)}_{s,p}$ and the total phase function $S^{(2)}$. The phase function resulting from $S^{(2)} + S^{(1)}$ is shown in Fig. 4.

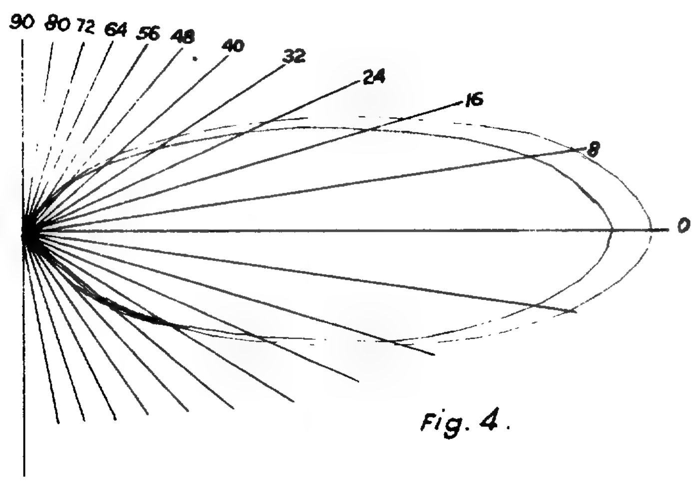


Fig. 4.

5. Several Internal Reflections

The procedure adopted is the same as for one internal reflection. The amount of light in the K-th case is $dF^o\, d^2\, r^{k-2}$. This is spread over a zone given by $ds^{(k)} = 2\pi R^2 \sin \beta^{(k)} d\beta^{(k)}$ and then $d\beta^{(K)}$ is computed as

$$d\beta^{(k)} = \frac{d\beta^{(k)}}{d\varphi} d\varphi = 2\left[1 - \frac{k-1}{n}\frac{\cos \varphi}{\cos \psi}\right] d\varphi$$

It is found that $\frac{d^{(k)}}{d\varphi}$ changes sign for certain values of φ and at those points where it is zero, we observe rainbows.

The value $d^{(k)}/d\varphi$ appears in the denominator of the intensity $\frac{dF^{(k)}}{dS^{(k)}}$ and this intensity therefore becomes formally infinitely large. The geometrical theory fails in these directions and we require the formulas of the wave theory to cope with these difficulties.

6. Connection with the Theory of Rainbows

Table 1 gives the data for successive rainbows, including their polarization which is always large. For successive values of (k) the angle φ increases, approaching in the limit the value $\varphi = \pi/2$. At the same time the angles of refraction ψ also increase, and approach $\psi = 48^\circ 45' 08''$.

7. Distribution of Energy among Scatterings of Different Degrees

The necessary formulae result from the preceding discussion. Table 2 gives the result.

TABLE 2

K	1	2	3	4	5	6	7	8	9	10	Σ
s rays	10.111	82.324	6.117	0.962	.264	.102	.048	.025	.015	.009	99.977
p rays	3.074	94.643	1.877	0.255	.076	.029	.015	.008	.005	.003	29.985
Total	6.592	88.483	3.997	0.608	.170	.066	.032	.016	.010	.006	99.981

6.6 per cent is reflected from the drop; 88.5 per cent passes through it; 4 per cent experiences an internal reflection, etc. The rainbows contain less than 5 per cent.

8. The Total Phase Function and the Polarization of the Scattered Light

The results are given in a long table. The ratio of light scattered forward to that backward in 168. Nearly all scattered radiation is contained within a cone of 65°.

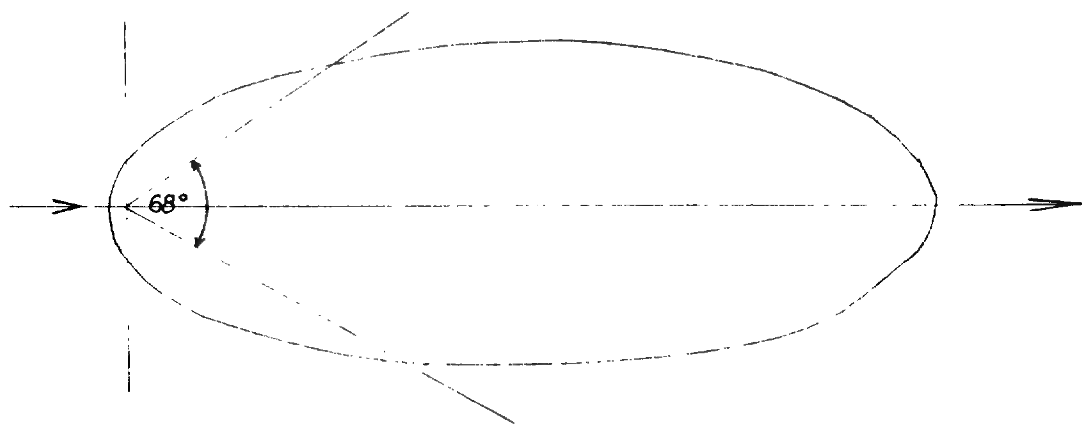


Fig. 7 shows the final phase function with the positions of the various rainbows.

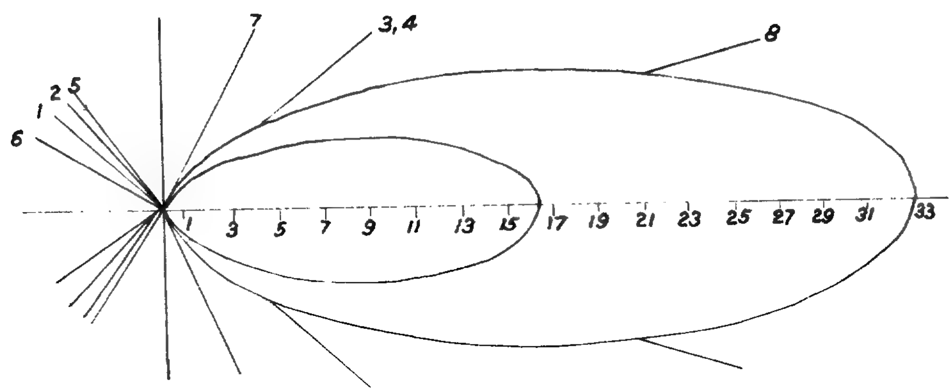


Fig. 7

Total phase function for large water droplets. The small curve is for the p rays above.

TABLE 3

β	r_s	$-T_s^{(1)}$	$T_s^{(2)}$	$T_s^{(3)}$	$T_s^{(4)}$	$T_s^{(5)}$	$T_s^{(6)}$	$T_s^{(7)}$	$T_s^{(8)}$	$T_s^{(9)}$	$T_s^{(10)}$
0		1.0000	15.5982		0.0002						
1		0.9610	15.5680		0.0002	0.0071 0.0037 0.0108					
2		0.9233	15.4783		0.0002	0.0057 0.0027 0.0084					
3		0.8875	15.3297		0.0002	0.0042 0.0024 0.0066					
4		0.8527	15.1255		0.0002	0.0030 0.0020 0.0050					
5		0.3195	14.8686		0.0002	0.0016 0.0027 0.0043					
6		0.7877	14.5631		0.0002	0.0024 0.0014 0.0038					
7		0.7571	14.2134		0.0002	0.0022 0.0012 0.0034					
8		0.7277	13.8249		0.0002	0.0020 0.0010 0.0030					
9		0.6995	13.4024		0.0002	0.0019 0.0008 0.0027					
10		0.6723	12.9519		0.0002	0.0018 0.0007 0.0025					
11		0.6464	12.4785		0.0002	0.0018 0.0006 0.0024					

Table 3 (Continued)

β	$r_s = T_s^{(1)}$	$T_s^{(2)}$	$T_s^{(3)}$	$T_s^{(4)}$	$T_s^{(5)}$	$T_s^{(6)}$	$T_s^{(7)}$	$T_s^{(8)}$	$T_s^{(9)}$	$T_s^{(10)}$
12	0.6215	11.9879		0.0003	0.0017					
					0.0005					
					0.0022					
13	0.5976	11.4851		0.0003	0.0017					
					0.0004					
					0.0021					
14	0.5746	10.9749		0.0003	0.0016					
					0.0004					
					0.0020					
15	0.5525	10.4618		0.0003	0.0017					
					0.0003					
					0.0020					
16	0.5314	9.9499		0.0003	0.0018					
					0.0002					
					0.0020					
17	0.5112	9.4427		0.0003	0.0018					0.0250
					0.0002					0.0128
					0.0020					0.0378
18	0.4917	8.9433		0.0003	0.0018					0.0038
					0.0002					0.0027
					0.0020					0.0065
19	0.4731	8.4545		0.0003	0.0018					0.0019
					0.0002					0.0015
					0.0020					0.0034
20	0.4552	7.9784		0.0003	0.0019					0.0007
					0.0002					0.0008
					0.0021					0.0015
21	0.4380	7.5167		0.0003	0.0019					0.0002
					0.0002					0.0005
					0.0021					0.0007
22	0.4216	7.0710		0.0003	0.0020					0.0000
					0.0002					0.0004
					0.0022					0.0004

Table 3 (Continued)

β	$r_s = T_s^{(1)}$	$T_s^{(2)}$	$T_s^{(3)}$	$T_s^{(4)}$	$T_s^{(5)}$	$T_s^{(6)}$	$T_s^{(7)}$	$T_s^{(8)}$	$T_s^{(9)}$	$T_s^{(10)}$
23	0.4058	6.6424		0.0003	0.0022 0.0002 0.0024					0.0003
24	0.3907	6.2312		0.0003	0.0023 0.0002 0.0025					0.0002
25	0.3762	5.8383		0.0003	0.0024 0.0001 0.0025					0.0001
26	0.3623	5.4637		0.0003	0.0025 0.0001 0.0026					0.0001
27	0.3490	5.1075		0.0003	0.0026 0.0001 0.0027					0.0001
28	0.3362	4.7695		0.0003	0.0029 0.0001 0.0030					
29	0.3239	4.4494		0.0003	0.0033 0.0001 0.0034					
30	0.3122	4.1467		0.0003	0.0037 0.0001 0.0038					
31	0.3010	3.8610		0.0003	0.0001 0.0001 0.0041 0.0043					
32	0.2901	3.5916		0.0003	0.0002 0.0003 0.0044 0.0049					
33	0.2796	3.3380		0.0003	0.0002 0.0010 0.0047 0.0059					

Table 3 (Continued)

β	$r_s = T_s^{(1)}$	$T_s^{(2)}$	$T_s^{(3)}$	$T_s^{(4)}$	$T_s^{(5)}$	$T_s^{(6)}$	$T_s^{(7)}$	$T_s^{(8)}$	$T_s^{(9)}$	$T_s^{(10)}$
34	0.2694	3.0995		0.0003	0.0001					
					0.0023					
					0.0053					
					0.0077					
35	0.2601	2.8755		0.0003	0.0001					
					0.0043					
					0.0061					
					0.0105					
36	0.2511	2.6651		0.0003	0.0067					
					0.0069					
					0.0136					
37	0.2425	2.4678		0.0003	0.0106					
					0.0082					
					0.0188					
38	0.2339	2.2829		0.0003	0.0151					
					0.0098					
					0.0249					
39	0.2258	2.1097		0.0003	0.0207					
					0.0117					
					0.0324					
40	0.2180	1.9475		0.0003	0.0281					
					0.0157					
					0.0438					
41	0.2106	1.7958		0.0003	0.0371					
					0.0222					
					0.0593					
42	0.2034	1.6542		0.0003	0.0585					
					0.0338					
					0.0923					
43	0.1966	1.5215		0.0003		0.0275				
						0.0856				
						0.1131				
44	0.1900	1.3977		0.0004		0.0156				
						0.0223				
						0.0379				

Table 3 (Continued)

β	$r_s = T_s^{(1)}$	$T_s^{(2)}$	$T_s^{(3)}$	$T_s^{(4)}$	$T_s^{(5)}$	$T_s^{(6)}$	$T_s^{(7)}$	$T_s^{(8)}$	$T_s^{(9)}$	$T_s^{(10)}$
45	0.1837	1.2822		0.0004		0.0105 0.0128 0.0233				
46	0.1776	1.1744		0.0004		0.0065 0.0084 0.0149				
47	0.1718	1.0739		0.0004		0.0038 0.0058 0.0096				
48	0.1662	0.9803		0.0004		0.0025 0.0048 0.0073				
49	0.1608	0.8932		0.0004		0.0016 0.0033 0.0049				
50	0.1557	0.8121		0.0004		0.0008 0.0030 0.0038				
51	0.1507	0.7367		0.0004		0.0005 0.0022 0.0027				
52	0.1459	0.6668		0.0004		0.0003 0.0019 0.0022				
53	0.1414	0.6018		0.0004		0.0015				
54	0.1370	0.5417		0.0004		0.0013				
55	0.1327	0.4861		0.0004		0.0010			0.0001	
56	0.1287	0.4347		0.0004		0.0009			0.0001	
57	0.1248	0.3873		0.0005		0.0008			0.0001	
58	0.1210	0.3437		0.0005		0.0006			0.0001	
59	0.1174	0.3037		0.0005		0.0005			0.0002	

Table 3 (Continued)

β	$r_s = T_s^{(1)}$	$T_s^{(2)}$	$T_s^{(3)}$	$T_s^{(4)}$	$T_s^{(5)}$	$T_s^{(6)}$	$T_s^{(7)}$	$T_s^{(8)}$	$T_s^{(9)}$	$T_s^{(10)}$
60	0.1139	0.2670		0.0005		0.0004			0.0002	
61	0.1106	0.2335		0.0005		0.0003			0.0000 0.0002 0.0002	
62	0.1074	0.2030		0.0005		0.0003			0.0002 0.0003 0.0005	
63	0.1042	0.1753		0.0005		0.0002			0.0006 0.0004 0.0010	
64	0.1013	0.1503		0.0005		0.0002			0.0011 0.0006 0.0017	
65	0.0984	0.1278		0.0006		0.0002			0.0018 0.0013 0.0031	
66	0.0956	0.1076		0.0006		0.0002			0.0060 0.0039 0.0099	
67	0.0930	0.0897		0.0006		0.0002				
68	0.0904	0.0738		0.0006		0.0001				
69	0.0879	0.0600		0.0006		0.0001				
70	0.0855	0.0480		0.0006		0.0001				
71	0.0833	0.0377		0.0007		0.0001				
72	0.0810	0.0289		0.0007		0.0001				
73	0.0789	0.0216		0.0007		0.0001				
74	0.0769	0.0156		0.0008		0.0001				
75	0.0749	0.0108		0.0008		0.0001				
76	0.0730	0.0071		0.0008		0.0001				

Table 3 (Continued)

β	$r_s = T_s^{(1)}$	$T_s^{(2)}$	$T_s^{(3)}$	$T_s^{(4)}$	$T_s^{(5)}$	$T_s^{(6)}$	$T_s^{(7)}$	$T_s^{(8)}$	$T_s^{(9)}$	$T_s^{(10)}$
77	0.0712	0.0043		0.0008		0.0001				
78	0.0693	0.0024		0.0009		0.0001				
79	0.0676	0.0011		0.0009		0.0001				
80	0.0660	0.0004		0.0009		0.0001				
81	0.0644	0.0001		0.0010		0.0000				
82	0.0629	0.0000		0.0010						
83	0.0614			0.0010						
84	0.0599			0.0011						
85	0.0586			0.0011						
86	0.0572			0.0012						
87	0.0559			0.0012						
88	0.0547			0.0013						
89	0.0535			0.0014						
90	0.0523			0.0014						
91	0.0512			0.0015						
92	0.0501			0.0015						
93	0.0490			0.0016						
94	0.0480			0.0017						
95	0.0470			0.0018						
96	0.0461			0.0019						
97	0.0452			0.0020						
98	0.0443			0.0022						
99	0.0434			0.0023						

Approved For Release 1999/09/01 : CIA-RDP79-00202A000100040001-2

Table 3 (Continued)

β	$r_s = T_s^{(1)}$	$T_s^{(2)}$	$T_s^{(3)}$	$T_s^{(4)}$	$T_s^{(5)}$	$T_s^{(6)}$	$T_s^{(7)}$	$T_s^{(8)}$	$T_s^{(9)}$	$T_s^{(10)}$
100	0.0426			0.0024						
101	0.0418			0.0025						
102	0.0410			0.0026						
103	0.0402			0.0028						
104	0.0395			0.0030						
105	0.0388			0.0032						
106	0.0381			0.0034						
107	0.0374			0.0037						
108	0.0368			0.0040						
109	0.0362			0.0043						
110	0.0356			0.0047						
111	0.0350			0.0051						
112	0.0344			0.0002 0.0054 0.0056						
113	0.0339			0.0007 0.0055 0.0062						
114	0.0333			0.0009 0.0060 0.0069						
115	0.0328			0.0010 0.0068 0.0078						
116	0.0323			0.0016 0.0075 0.0091						

Table 3 (Continued)

βr_s	$T_s^{(1)}$	$T_s^{(2)}$	$T_s^{(3)}$	$T_s^{(4)}$	$T_s^{(5)}$	$T_s^{(6)}$	$T_s^{(7)}$	$T_s^{(8)}$	$T_s^{(9)}$	$T_s^{(10)}$
117	0.0318			0.0020						
				0.0088						
				0.0108						
118	0.0313			0.0032						
				0.0099						
				0.0131						
119	0.0309			0.0056						
				0.0107						
				0.0163						
120	0.0305			0.0092						
				0.0115						
				0.0207						
121	0.0301			0.0123						
				0.0143						
				0.0266						
122	0.0297			0.0180						
				0.0160						
				0.0340						
123	0.0293			0.0247						
				0.0189						
				0.0435						
124	0.0289			0.0332						
				0.0228						
				0.0560						
125	0.0285			0.0433						
				0.0275						
				0.0708						
126	0.0281			0.0553						
				0.0340						
				0.0893						
127	0.0277			0.0701			0.0144			
				0.0448			0.0091			
				0.1149			0.0235			

Table 3 (Continued)

β	$r_s = T_s^{(1)}$	$T_s^{(2)}$	$T_s^{(3)}$	$T_s^{(4)}$	$T_s^{(5)}$	$T_s^{(6)}$	$T_s^{(7)}$	$T_s^{(8)}$	$T_s^{(9)}$	$T_s^{(10)}$
128	0.0274			0.0959 0.0629 0.1583			0.0076 0.0042 0.0118			
129	0.0271			0.1472 0.0990 0.2462			0.0047 0.0026 0.0073			
130	0.0268						0.0028 0.0018 0.0046			
131	0.0265						0.0016 0.0015 0.0031			
132	0.0262						0.0006 0.0011 0.0017	0.0001		
133	0.0259						0.0002 0.0008 0.0010	0.0001		
134	0.0256						0.0001 0.0006 0.0007	0.0001		
135	0.0253						0.0000 0.0005 0.0005	0.0001		
136	0.0250						0.0004	0.0001		
137	0.0247						0.0003	0.0001		
138	0.0245		0.9841 0.8755 1.8596				0.0003	0.0002		
139	0.0243		0.6229 0.5040 1.1269				0.0002	0.0002		

Table 3 (Continued)

β	$r_s = T_s^{(1)}$	$T_s^{(2)}$	$T_s^{(3)}$	$T_s^{(4)}$	$T_s^{(5)}$	$T_s^{(6)}$	$T_s^{(7)}$	$T_s^{(8)}$	$T_s^{(9)}$	$T_s^{(10)}$
140	0.0241		0.5160				0.0002	0.0002		
			0.3910							
			0.9070							
141	0.0239		0.4215				0.0002	0.0002		
			0.3210							
			0.7425							
142	0.0237		0.3565				0.0002	0.0003		
			0.2759							
			0.6324							
143	0.0235		0.3115				0.0002	0.0001		
			0.2420					0.0004		
			0.5535					0.0005		
144	0.0233		0.2785				0.0002	0.0002		
			0.2187					0.0005		
			0.4972					0.0007		
145	0.0231		0.2485				0.0001	0.0004		
			0.1980					0.0007		
			0.4465					0.0011		
146	0.0229		0.2168				0.0001	0.0011		
			0.1797					0.0010		
			0.3965					0.0021		
147	0.0228		0.1812				0.0001	0.0018		
			0.1685					0.0016		
			0.3497					0.0034		
148	0.0226		0.1655				0.0001	0.0038		
			0.1570					0.0017		
			0.3225					0.0055		
149	0.0224		0.1420				0.0001	0.0110		
			0.1471					0.0060		
			0.2891					0.0170		
150	0.0222		0.1221				0.0001			
			0.1398							
			0.2619							

Table 3 (Continued)

βr_s	$T_s^{(1)}$	$T_s^{(2)}$	$T_s^{(3)}$	$T_s^{(4)}$	$T_s^{(5)}$	$T_s^{(6)}$	$T_s^{(7)}$	$T_s^{(8)}$	$T_s^{(9)}$	$T_s^{(10)}$
151	0.0220		0.1055				0.0001			
			0.1326							
			0.2381							
152	0.0219		0.0905				0.0001			
			0.1260							
			0.2165							
153	0.0218		0.0757				0.0001			
			0.1211							
			0.1968							
154	0.0217		0.0621				0.0001			
			0.1162							
			0.1783							
155	0.0216		0.0499				0.0001			
			0.1125							
			0.1624							
156	0.0215		0.0383				0.0001			
			0.1080							
			0.1463							
157	0.0214		0.0290				0.0001			
			0.1040							
			0.1330							
158	0.0213		0.0202				0.0001			
			0.1012							
			0.1214							
159	0.0212		0.0128				0.0001			
			0.0988							
			0.1116							
160	0.0211		0.0070				0.0001			
			0.0965							
			0.1035							
161	0.0210		0.0026				0.0001			
			0.0939							
			0.0965							

Table 3 (Continued)

β	$r_s = T_s^{(1)}$	$T_s^{(2)}$	$T_s^{(3)}$	$T_s^{(4)}$	$T_s^{(5)}$	$T_s^{(6)}$	$T_s^{(7)}$	$T_s^{(8)}$	$T_s^{(9)}$	$T_s^{(10)}$
162	0.0209		0.0014 0.0924 0.0938				0.0001			
163	0.0208		0.0004 0.0910 0.0914				0.0001			
164	0.0207		0.0894				0.0001			
165	0.0206		0.0877							
166	0.0205		0.0860							
167	0.0205		0.0844							
168	0.0204		0.0829							
169	0.0204		0.0815							
170	0.0203		0.0804							
171	0.0203		0.0793							
172	0.0202		0.0785							
173	0.0202		0.0779							
174	0.0201		0.0775							
175	0.0201		0.0771							
176	0.0201		0.0768							
177	0.0201		0.0765							
178	0.0201		0.0762							
179	0.0201		0.0760							
180	0.0201		0.0758							

TABLE 4

β	$r_p = T_p^{(1)}$	$T_p^{(2)}$	$T_p^{(3)}$	$T_p^{(4)}$	$T_p^{(5)}$	$T_p^{(6)}$	$T_p^{(7)}$	$T_p^{(8)}$	$T_p^{(9)}$	$T_p^{(10)}$
0	1.0000	15.5982		0.0002						
1	0.9321	15.5703		0.0002						
2	0.8686	15.4875		0.0002						
3	0.8095	15.3507		0.0002						
4	0.7542	15.1624		0.0002						
5	0.7030	14.9254		0.0002						
6	0.6550	14.6432		0.0002						
7	0.6103	14.3200		0.0002						
8	0.5685	13.9604		0.0002						
9	0.5295	13.5690		0.0002						
10	0.4931	13.1510		0.0002						
11	0.4591	12.7110		0.0002						
12	0.4274	12.2542		0.0002						
13	0.3978	11.7852		0.0002						
14	0.3701	11.3083		0.0002						
15	0.3443	10.8276		0.0002						
16	0.3202	10.3468		0.0002						
17	0.2976	9.8692		0.0002						0.0039 0.0014 0.0053
18	0.2766	9.3976		0.0002						0.0030 0.0004 0.0034
19	0.2570	8.9346		0.0002						0.0022 0.0001 0.0023

Table 4 (Continued)

β	$r_p = T_p^{(1)}$	$T_p^{(2)}$	$T_p^{(3)}$	$T_p^{(4)}$	$T_p^{(5)}$	$T_p^{(6)}$	$T_p^{(7)}$	$T_p^{(8)}$	$T_p^{(9)}$	$T_p^{(10)}$
20	0.2386	8.4822		0.0002						0.0013
21	0.2216	8.0420		0.0002						0.0005
22	0.2055	7.6155		0.0002						0.0001
23	0.1906	7.2035		0.0002						
24	0.1767	6.8070		0.0002						
25	0.1637	6.4263		0.0002						
26	0.1516	6.0617		0.0002						
27	0.1402	5.7133		0.0002						
28	0.1297	5.3809		0.0002						
29	0.1198	5.0645		0.0002						
30	0.1107	4.7635		0.0002						
31	0.1021	4.4777		0.0002	0.0000					
32	0.0941	4.2066		0.0002	0.0009					
33	0.0867	3.9495		0.0002	0.0025					
34	0.0798	3.7060		0.0002	0.0044					
35	0.0734	3.4756		0.0002	0.0065					
36	0.0673	3.2575		0.0002	0.0095					
37	0.0618	3.0513		0.0002	0.0123 0.0000 0.0123					
38	0.0566	2.8563		0.0002	0.0144 0.0001 0.0145					
39	0.0518	2.6719		0.0002	0.0158 0.0002 0.0160					
40	0.0473	2.4977		0.0002	0.0165 0.0003 0.0168					

Table 4 (Continued)

β	$r_p = T_p^{(1)}$	$T_p^{(2)}$	$T_p^{(3)}$	$T_p^{(4)}$	$T_p^{(5)}$	$T_p^{(6)}$	$T_p^{(7)}$	$T_p^{(8)}$	$T_p^{(9)}$	$T_p^{(10)}$
41	0.0431	2.3330		0.0002	0.0171 0.0005 0.0176					
42	0.0393	2.1774		0.0002	0.0177 0.0014 0.0191					
43	0.0357	2.0302		0.0002		0.0088 0.0010 0.0098				
44	0.0324	1.8915		0.0002		0.0080 0.0003 0.0083				
45	0.0294	1.7599		0.0002		0.0075 0.0001 0.0076				
46	0.0265	1.6357		0.0002		0.0060				
47	0.0239	1.5185		0.0002		0.0044				
48	0.0215	1.4074		0.0002		0.0031				
49	0.0193	1.3027		0.0002		0.0021				
50	0.0172	1.2036		0.0002		0.0014				
51	0.0153	1.1101		0.0002		0.0007				
52	0.0136	1.0217		0.0002		0.0002				
53	0.0120	0.9382		0.0002						
54	0.0106	0.8595		0.0002						
55	0.0093	0.7852		0.0002						
56	0.0081	0.7152		0.0002						
57	0.0070	0.6494		0.0002						
58	0.0060	0.5874		0.0002						

Table 4 (Continued)

β	$r_p = T_p^{(1)}$	$T_p^{(2)}$	$T_p^{(3)}$	$T_p^{(4)}$	$T_p^{(5)}$	$T_p^{(6)}$	$T_p^{(7)}$	$T_p^{(8)}$	$T_p^{(9)}$	$T_p^{(10)}$
59	0.0052	0.5292		0.0002						
60	0.0044	0.4747		0.0002						
61	0.0037	0.4236		0.0002					0.0001	
62	0.0030	0.3760		0.0001					0.0004	
63	0.0025	0.3317		0.0001					0.0008 0.0000 0.0008	
64	0.0020	0.2906		0.0001					0.0012 0.0000 0.0012	
65	0.0016	0.2526		0.0001					0.0016 0.0000 0.0016	
66	0.0012	0.2176		0.0001					0.0017 0.0002 0.0019	
67	0.0009	0.1855		0.0001						
68	0.0006	0.1564		0.0001						
69	0.0004	0.1301		0.0001						
70	0.0002	0.1066		0.0001						
71	0.0002	0.0357		0.0001						
72	0.0000	0.0674		0.0001						
73	0.0000	0.0516		0.0001						
74	0.0000	0.0383		0.0001						
75	0.0000	0.0272		0.0001						
76	0.0000	0.0184		0.0001						
77	0.0002	0.0116		0.0001						

Table 4 (Continued)

β	$r_p = T_p^{(1)}$	$T_p^{(2)}$	$T_p^{(3)}$	$T_p^{(4)}$	$T_p^{(5)}$	$T_p^{(6)}$	$T_p^{(7)}$	$T_p^{(8)}$	$T_p^{(9)}$	$T_p^{(10)}$
78	0.0002	0.0066		0.0001						
79	0.0004	0.0032		0.0001						
80	0.0005	0.0012		0.0001						
81	0.0007	0.0003		0.0001						
82	0.0008			0.0001						
83	0.0010			0.0001						
84	0.0012			0.0001						
85	0.0015			0.0001						
86	0.0017			0.0001						
87	0.0020									
88	0.0022									
89	0.0025									
90	0.0027									
91	0.0030									
92	0.0033									
93	0.0036									
94	0.0039									
95	0.0042									
96	0.0045									
97	0.0048									
98	0.0051									
99	0.0054									
100	0.0057									

Table 4 (Continued)

ρ	$r_p = T_p^{(1)}$	$T_p^{(2)}$	$T_p^{(3)}$	$T_p^{(4)}$	$T_p^{(5)}$	$T_p^{(6)}$	$T_p^{(7)}$	$T_p^{(8)}$	$T_p^{(9)}$	$T_p^{(10)}$
101	0.0061									
102	0.0064									
103	0.0067									
104	0.0070									
105	0.0073									
106	0.0076									
107	0.0079									
108	0.0082									
109	0.0085									
110	0.0088									
111	0.0091									
112	0.0094									
113	0.0097			0.0000						
114	0.0100			0.0002						
115	0.0103			0.0010						
116	0.0106			0.0023						
117	0.0109			0.0045						
118	0.0112			0.0075						
119	0.0115			0.0106						
120	0.0118			0.0141						
121	0.0120			0.0179						
122	0.0123			0.0214						
123	0.0125			0.0246						

Table 4 (Continued)

β	$r_p = T_p^{(1)}$	$T_p^{(2)}$	$T_p^{(3)}$	$T_p^{(4)}$	$T_p^{(5)}$	$T_p^{(6)}$	$T_p^{(7)}$	$T_p^{(8)}$	$T_p^{(9)}$	$T_p^{(10)}$
124	0.0128			0.0276						
125	0.0130			0.0300 0.0001 0.0301						
126	0.0133			0.0322 0.0002 0.0324						
127	0.0135			0.0340 0.0005 0.0345			0.0044 0.0007 0.0051			
128	0.0138			0.0360 0.0012 0.0372			0.0042 0.0001 0.0043			
129	0.0140			0.0380 0.0029 0.0409			0.0038			
130	0.0143						0.0030			
131	0.0145						0.0022			
132	0.0147						0.0013			
133	0.0149						0.0005			
134	0.0151						0.0001			
135	0.0153						0.0000			
136	0.0155									
137	0.0157									
138	0.0159		0.1500 0.0090 0.1590							
139	0.0161		0.1498 0.0020 0.1518							

Table 4 (Continued)

β	$r_p = T_p^{(1)}$	$T_p^{(2)}$	$T_p^{(3)}$	$T_p^{(4)}$	$T_p^{(5)}$	$T_p^{(6)}$	$T_p^{(7)}$	$T_p^{(8)}$	$T_p^{(9)}$	$T_p^{(10)}$
140	0.0163		0.1565 0.0080 0.1645							
141	0.0165		0.1620 0.0140 0.1760							
142	0.0167		0.1665 0.0195 0.1860							
143	0.0169		0.1695 0.0245 0.1940					0.0001		
144	0.0171		0.1700 0.0287 0.1987					0.0003		
145	0.0173		0.1692 0.0325 0.2017					0.0009		
146	0.0175		0.1670 0.0365 0.2035					0.0019		
147	0.0176		0.1620 0.0393 0.2013					0.0029		
148	0.0178		0.1560 0.0419 0.1979					0.0036 0.0001 0.0037		
149	0.0179		0.1485 0.0444 0.1929					0.0042 0.0003 0.0045		
150	0.0180		0.1395 0.0470 0.1865							

Approved For Release 1999/09/01 : CIA-RDP79-00202A000100040001-2

Table 4 (Continued)

β	$r_p = T_p^{(1)}$	$T_p^{(2)}$	$T_p^{(3)}$	$T_p^{(4)}$	$T_p^{(5)}$	$T_p^{(6)}$	$T_p^{(7)}$	$T_p^{(8)}$	$T_p^{(9)}$	$T_p^{(10)}$
151	0.0181		0.1295							
			0.0500							
			0.1795							
152	0.0182		0.1185							
			0.0525							
			0.1710							
153	0.0183		0.1069							
			0.0542							
			0.1611							
154	0.0184		0.0930							
			0.0560							
			0.1490							
155	0.0185		0.0790							
			0.0580							
			0.1370							
156	0.0186		0.0656							
			0.0596							
			0.1252							
157	0.0187		0.0525							
			0.0610							
			0.1135							
158	0.0188		0.0405							
			0.0630							
			0.1035							
159	0.0189		0.0300							
			0.0638							
			0.0938							
160	0.0190		0.0215							
			0.0650							
			0.0865							
161	0.0191		0.0120							
			0.0665							
			0.0785							

Table 4 (Continued)

β	$r_p = T_p^{(1)}$	$T_p^{(2)}$	$T_p^{(3)}$	$T_p^{(4)}$	$T_p^{(5)}$	$T_p^{(6)}$	$T_p^{(7)}$	$T_p^{(8)}$	$T_p^{(9)}$	$T_p^{(10)}$
162	0.0192		0.0055 0.0680 0.0735							
163	0.0193		0.0017 0.0690 0.0707							
164	0.0194		0.0001 0.0700 0.0701							
165	0.0195		0.0000 0.0703 0.0703							
166	0.0196		0.0707							
167	0.0197		0.0712							
168	0.0197		0.0718							
169	0.0198		0.0725							
170	0.0198		0.0732							
171	0.0199		0.0738							
172	0.0199		0.0744							
173	0.0200		0.0749							
174	0.0200		0.0751							
175	0.0200		0.0753							
176	0.0200		0.0754							
177	0.0200		0.0755							
178	0.0200		0.0756							
179	0.0201		0.0757							
180	0.0201		0.0758							

TABLE 5

β	T_s	T_p	$T = T_s + T_p$	P
0	16.5984	16.5984	33.1968	0.0000
1	16.5400	16.5026	33.0426	.0011
2	16.4102	16.3563	32.7665	.0016
3	16.2240	16.1604	32.3844	.0020
4	15.9834	15.9168	31.9002	.0021
5	15.6926	15.6286	31.3212	.0020
6	15.3548	15.2984	30.7532	.0018
7	14.9741	14.9305	29.9046	.0014
8	14.5558	14.5291	29.0849	.0009
9	14.1048	14.0987	28.2035	.0002
10	13.6269	13.6443	27.2712	-0.0006
11	13.1275	13.1703	26.2978	- .0017
12	12.6119	12.6318	25.2937	- .0028
13	12.0851	12.1832	24.2683	- .0040
14	11.5518	11.6786	22.2304	- .0055
15	11.0166	11.1721	22.1887	- .0070
16	10.4836	10.6672	21.1508	- .0087
17	9.9940	10.1723	20.1663	- .0088
18	9.4438	9.6778	19.1216	- .0122
19	8.9333	9.1941	18.1274	- .0144
20	8.4375	8.7223	17.1598	- .0166
21	7.9578	8.2643	16.2221	- .0189
22	7.4955	7.8213	15.3168	- .0213
23	7.0512	7.3943	14.4455	- .0238
24	6.6249	6.9839	13.6088	- .0264
25	6.2174	6.5902	12.8076	- .0291
26	5.8290	6.2135	12.0425	- .0319
27	5.4596	5.8537	11.3133	- .0348
28	5.1090	5.5107	10.6197	- .0378
29	4.7770	5.1845	9.9615	- .0409
30	4.4630	4.8744	9.3374	- .0441
31	4.1666	4.5800	8.7466	- .0473
32	3.8869	4.3018	8.1887	- .0507
33	3.6238	4.0389	7.6627	- .0542
34	3.3769	3.7904	7.1673	- .0577
35	3.1463	3.5557	6.7020	- .0611
36	2.9301	3.3345	6.2646	- .0646
37	2.7294	3.1256	5.8550	- .0677
38	2.5420	2.9276	5.4696	- .0707
39	2.3682	2.7399	5.1081	- .0728
40	2.2096	2.5620	4.7716	- .0738
41	2.0660	2.3939	4.4599	- .0735
42	1.9502	2.2360	4.1862	- .0683
43	1.8315	2.0759	3.9074	- .0628
44	1.6260	1.9324	3.5584	- .0861

Table 5 .(Continued)

β	T_s	T_p	$T = T_s + T_p$	P
45	1.4896	1.7971	3.2867	-0.0935
46	1.3673	1.6684	3.0357	- .0992
47	1.2557	1.5470	2.8027	- .1040
48	1.1542	1.4322	2.5864	- .1075
49	1.0593	1.3243	2.3836	- .1115
50	0.9720	1.2224	2.1944	- .1141
51	.8905	1.1263	2.0168	- .1169
52	.8153	1.0357	1.8510	- .1191
53	.7451	0.9504	1.6955	- .1210
54	.6804	.8703	1.5507	- .1225
55	.6203	.7948	1.4151	- .1235
56	.5648	.7235	1.2883	- .1231
57	.5135	.6566	1.1701	- .1223
58	.4659	.5936	1.0595	- .1205
59	.4223	.5346	0.9569	- .1173
60	.3820	.4793	.8613	- .1130
61	.3451	.4276	.7727	- .1068
62	.3117	.3795	.6912	- .0981
63	.2812	.3351	.6163	- .0874
64	.2540	.2939	.5479	- .0728
65	.2301	.2559	.4860	- .0530
66	.2139	.2208	.4347	- .0159
67	.1835	.1865	.3700	- .0083
68	.1649	.1571	.3220	.0242
69	.1486	.1306	.2792	.0645
70	.1342	.1069	.2411	.1132
71	.1218	.0860	.2078	.1723
72	.1107	.0675	.1782	.2424
73	.1013	.0517	.1530	.3242
74	.0934	.0384	.1318	.4173
75	.0866	.0273	.1139	.5206
76	.0810	.0185	.0995	.6281
77	.0764	.0119	.0883	.7305
78	.0727	.0069	.0796	.8266
79	.0697	.0037	.0734	.8992
80	.0674	.0018	.0692	.9480
81	.0655	.0011	.0666	.9670
82	.0639	.0009	.0648	.9722
83	.0624	.0011	.0635	.9654
84	.0610	.0013	.0623	.9583
85	.0597	.0016	.0613	.9478
86	.0584	.0018	.0602	.9402
87	.0571	.0020	.0591	.9323
88	.0560	.0022	.0582	.9244
89	.0549	.0025	.0574	.9129
90	.0537	.0027	.0564	.9043

Table 5 (Continued)

β	T_s	T_p	$T = T_s + T_p$	P
91	0.0527	0.0030	0.0557	0.8923
92	.0516	.0033	.0549	.8798
93	.0506	.0034	.0542	.8672
94	.0497	.0039	.0536	.8545
95	.0488	.0042	.0530	.8415
96	.0480	.0045	.0525	.8286
97	.0472	.0048	.0520	.8154
98	.0465	.0051	.0516	.8023
99	.0457	.0051	.0511	.7886
100	.0450	.0057	.0507	.7751
101	.0443	.0061	.0504	.7579
102	.0436	.0064	.0500	.7440
103	.0430	.0067	.0497	.7304
104	.0425	.0070	.0495	.7172
105	.0420	.0073	.0493	.7038
106	.0415	.0076	.0491	.6904
107	.0411	.0079	.0490	.6776
108	.0408	.0082	.0490	.6653
109	.0405	.0085	.0490	.6531
110	.0403	.0088	.0491	.6415
111	.0401	.0091	.0492	.6301
112	.0400	.0094	.0494	.6194
113	.0400	.0097	.0497	.6096
114	.0402	.0102	.0504	.5952
115	.0406	.0113	.0519	.5645
116	.0414	.0129	.0543	.5249
117	.0426	.0154	.0580	.4690
118	.0444	.0187	.0631	.4073
119	.0472	.0221	.0693	.3622
120	.0512	.0259	.0771	.3281
121	.0567	.0299	.0866	.3095
122	.0637	.0337	.0974	.3080
123	.0728	.0371	.1099	.3258
124	.0849	.0404	.1253	.3551
125	.0993	.0431	.1424	.3947
126	.1174	.0457	.1631	.4396
127	.1661	.0531	.2192	.5155
128	.1975	.0553	.2528	.5625
129	.2806	.0587	.3393	.6540
130	.0314	.0173	.0487	.2895
131	.0296	.0167	.0463	.2894
132	.0280	.0160	.0440	.2727
133	.0270	.0154	.0424	.2735
134	.0264	.0152	.0416	.2692
135	.0259	.0153	.0412	.2572
136	.0255	.0156	.0410	.2439

Table 5 (Continued)

β	T_s	T_p	$T = T_s + T_p$	P
137	0.0251	0.0157	0.0408	0.2303
138	1.8846	.1749	2.0595	.8302
139	1.1516	.1679	1.3195	.7455
140	0.9315	.1808	1.1123	.6749
141	.7668	.1925	0.9593	.5986
142	.6566	.2027	.8593	.5283
143	.5777	.2110	.7887	.4649
144	.5214	.2161	.7375	.4139
145	.4708	.2199	.6907	.3632
146	.4216	.2229	.6445	.3083
147	.3760	.2218	.5978	.2579
148	.3507	.2194	.5701	.2478
149	.3286	.2153	.5439	.2083
150	.2842	.2045	.4887	.1631
151	.2601	.1976	.4577	.1365
152	.2385	.1892	.4277	.1152
153	.2187	.1794	.3981	.0987
154	.2001	.1674	.3675	.0890
155	.1841	.1555	.3396	.0842
156	.1679	.1438	.3117	.0780
157	.1545	.1322	.2867	.0778
158	.1428	.1223	.2651	.0774
159	.1329	.1127	.2456	.0762
160	.1247	.1055	.2302	.0834
161	.1176	.0975	.2152	.0929
162	.1148	.0927	.2075	.1065
163	.1123	.0900	.2023	.1102
164	.1102	.0895	.1997	.1036
165	.1083	.0898	.1981	.0934
166	.1065	.0903	.1968	.0824
167	.1049	.0909	.1958	.0715
168	.1033	.0915	.1948	.0605
169	.1019	.0923	.1942	.0494
170	.1007	.0930	.1937	.0398
171	.0996	.0937	.1933	.0305
172	.0987	.0943	.1930	.0228
173	.0981	.0949	.1930	.0166
174	.0976	.0951	.1927	.0130
175	.0972	.0953	.1925	.0098
176	.0969	.0954	.1923	.0078
177	.0966	.0955	.1921	.0057
178	.0963	.0956	.0919	.0036
179	.0961	.0958	.0919	.0015
180	.0959	.0959	.1918	.0000

PART B

E.V. Pyaskovskaya - Fesenkova: Some Data on the Optical Properties of Atmosphere under Mountain Conditions (Astronomicheskiy Zhurnal, T.29, Vyp. 3, p. 313, 1952).

The observations were made in several locations in the Soviet Union with a visual surface photometer constructed by V.G. Fesenkov. The observations give directly the ratio of the surface brightness of a given region in the sky to the brightness at the zenith. If the illumination from the sun on a unit area at right angles to the rays, outside the atmosphere, is $E_{\odot,o}$ and at the place of observations, $E_{\odot,m}$ then

$$E_{\odot,m} = E_{\odot,o}\, p^m$$

By measuring the illumination with the photometer we obtain directly

$$\alpha = B/E_{\odot,m}$$

Hence, in stilbs,

$$B = E_{\odot,o}\, p^m\, \alpha$$

The quantity $E_{\odot,o}$ is considered as a constant

$$E_{\odot,o} = 13{,}000 \text{ lux} = 13 \text{ phot.}$$

at $\lambda \sim 546$ mμ.

The author discusses four methods of determining p with a precision of one per cent. The first three are her own.

1) The brightness of the area around the sun increases from sunrise until it reaches a certain maximum value at zenith distance $Z_\odot$, after which it again decreases. At the time of maximum brightness $\ln p = -\frac{1}{m\ (\max)}$

where m (max) is the air mass at the appropriate moment. The <u>maximum brightness occurs at that moment at which the optical thickness of the atmosphere is equal to one</u>.

2) Let the phase function of scattering in the atmosphere be $\mu = \sigma f(\theta)$ and let

$$\tau = 2\pi \int_0^\pi \mu \sin\theta \, d\theta$$

be the luminous flux scattered in all directions, then τ is the optical thickness of the atmosphere and $p = e^{-\tau}$. The values of μ are found from the observations at different angular distances θ from the sun, at the sun's elevation above the horizon:

$$\mu = \sigma f(\theta) = \frac{B}{E_{\odot, m}} \frac{1}{m}$$

The phase function is normalized to give $f(90^\circ) = 1$. This method takes account only of first-order scattering processes.

3) An empirical formula based upon a large number of observations gives

$$p = 0.973 - 9.80\mu(60^\circ)$$

where μ is measured at $\theta = 60^\circ$. All that is required here is one measurement of the sky, on the almucantarat of the sun, at $\theta = 60^\circ$; and one comparison of a surface with known albedo with the zenith sky.

Al alternative formula for $\theta = 90^\circ$,

$$p = 0.977 - 14.08\mu(90^\circ)$$

is less accurate. Both expressions apply only to $476 < \lambda < 625$ mμ and $p > 0.75$.

4) The standard procedure of Bouguer depends upon direct measurements of the sun at different zenith distances. The results are plotted against the air mass, and the slope of the (nearly) straight line thus obtained gives p.

The observations at Kislovodsk (in the Caucasus mountains) and Alma Ata (in the mountainous desert of south-east Asia) are summarized in Table 1. The four methods give very accordant results for p. The author prefers methods (2) and (3) because they require less time and are therefore free of errors arising from a possible change of p with the time.

A new series of observations was carried out at a mountain station near Kislovodsk, altitude 2130 meters, and compared with similar observations at three different stations near Alma Ata (elevations of 400, 1400 and 3140 meters). All observations were made on clear days. The phase functions are shown in Figures 1 - 4 for the four locations. The observations were all adjusted to refer to one standard value of $p = 0.88$ ($\tau = 0.128$). Each diagram gives the total, observed values of μ and the computed Rayleigh component of the scattering which differs according to the altitude and the air mass above the observer. The difference between them is also plotted and represents the effect of scattering by the aerosols.

As a rule the scattering of light by the aerosols decreases with the height. But there are many exceptions and Fig. 1 - 4 illustrate three clearly. In the four diagrams the aerosol component is strongly asymmetrical, and directed forward, but its amount is greatest for the highest elevations, and smallest for the 400 meter altitude.

The density of the four values of p shows that the total amount of radiation removed from the incident beam was the same in these cases. But this does not mean that such an identity exists for each direction. The author had shown previously that for $50^{\circ} < \theta < 90^{\circ}$ or 100°, differences in the shape of the phase function produce only insignificant differences in the amounts of scattered radiation. But on both sides of this region ($\theta < 50^{\circ}$ and $\theta > 90^{\circ}$ or 100°) the differences become very significant. Thus for one

and the same p there may be a bright solar aura with a consequent dark spot at $\theta = 180^\circ$ or a relatively less pronounced difference between these two diametrically opposite regions. Such differences for equal values of p are often observed in central Asia and Kazakhstan.

This produces the following effect: If the scattering by the aerosols remains the same at different h, or if the phase function becomes less unsymmetrical at low h, then for equal values of p and identical horizontal coordinates of the sun, the solar aura becomes brighter with increasing h (and the spot at $\theta = 180^\circ$ becomes darker).

Table 4 shows for the four locations the brightness of the sky along the sun's almucantarat expressed in stilbs, and reduced to $m = 2.45$ ($\tau = 0.128$). The table also gives the aerosol component $f(\theta)$

θ	H = 3140 m		h = 2130 m		h = 1400 m		h = 400 m		Rayleigh
	B	$f(\theta)$	B	$f(\theta)$	B	$f(\theta)$	B	$f(\theta)$	
15°	0.60	5.45	0.59	6.25	0.55	5.99	0.44	3.87	0.34
20	.54	4.70	.52	5.09	.49	4.98	.39	3.07	.34
40	.35	2.67	.32	2.53	.33	2.73	.28	1.46	.28
60	.24	1.61	.24	1.69	.23	1.52	.22	1.11	.22
86	.18	1.12	.18	1.19	.18	1.17	.18	1.04	.18
90	.17	1.00	.17	1.00	.17	1.00	.18	1.00	.18
100	.17		--		.17		.18		.14
120	.18		.19		.18		.21		.22
140	.22		.22		.22		.25		.28

Although there are no observations for $\theta < 15^\circ$ it is certain that the lowest brightness near the sun was observed at h = 400 m - in the desert.

The shape of the phase function changes from day to day. But on the dates of observation it was less elongated at h = 400 m than at the other elevations (3.87/1 as against 6.25/1 for Kislovodsk, h = 2130 m). This, at first sight, anomalous result may find its explanation in the effect of dust storms which, according to A.P. Kutyreva, often produce brilliant auras around the sun in eastern Pamir at elevations of h = 5,000 m., while in the western Pamir at h = 2500 m this phenomenon is absent, due no doubt to the shielding from the winds by the high mountains in the east.

The author believes that the sky brightness would be least in a stony desert of high elevation. The sky in the zenith (which falls in the region $50^\circ < \theta < 90^\circ$ to 100°) is almost unaffected by differences in the shape of the phase function provided the air mass and p are the same. This is shown in Fig. 5, where for different zenith distances Z the measured quantity B (stilbs) or $B/B_\odot$ are essentially identical for h = 2130 m (crosses) and h = 400 m (dots). For both locations p = 0.88.

Figures 6 - 8 show the isophotes of the sky brightness in stilbs for Alma Ata on two dates, and for different zenith distances of the sun, $Z_\odot$. The construction of these curves from direct measurements requires 25 - 30 measurements, or 20 - 30 minutes of time, during which interval the sky changes appreciably when $Z_\odot$ is large. Hence the author has developed an empirical procedure based upon only 4 - 5 measurements at different values of θ.

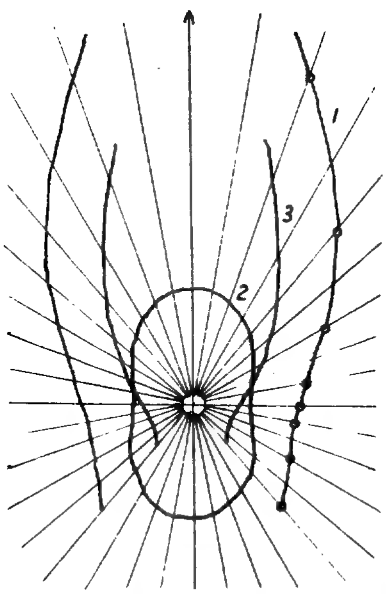


Fig. 1.
Kumbel mountain (Alma-Ata) $h=3140m.$ $p=0.88$

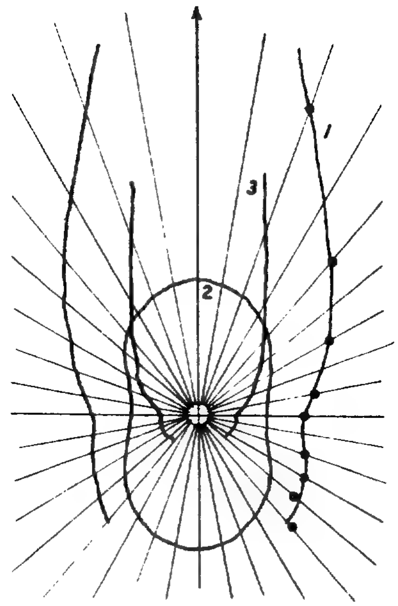


Fig. 2.
Mountain[redacted] astronomic station GAO (Kislovodsk) $h=2130m.$ $p=0.88$

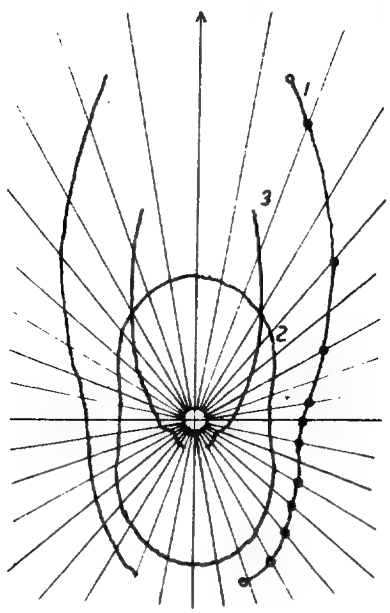


Fig. 3.
Mountain[redacted] astrophysical sta. (Alma-Ata) $h=1400m.$ $p=0.88$

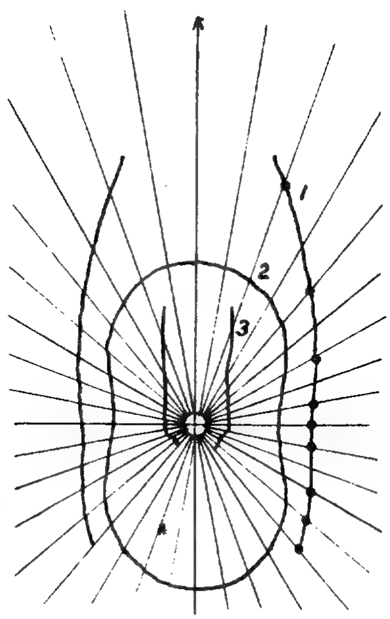


Fig. 4.
South Pribalkhash desert (Sary-Ishik-Otrau sands) $h=400m.$ $p=0.88$

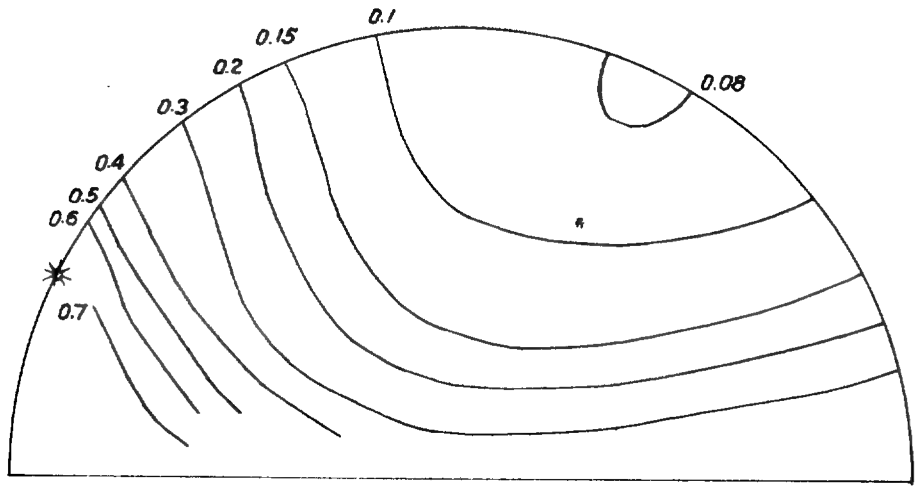


Fig. 7 - Clear daylight sky in stilbs 28 VI 1951.

$Z_{\odot} = 65°5$ $\quad p = 0.88$ $\quad$ Alma Ata

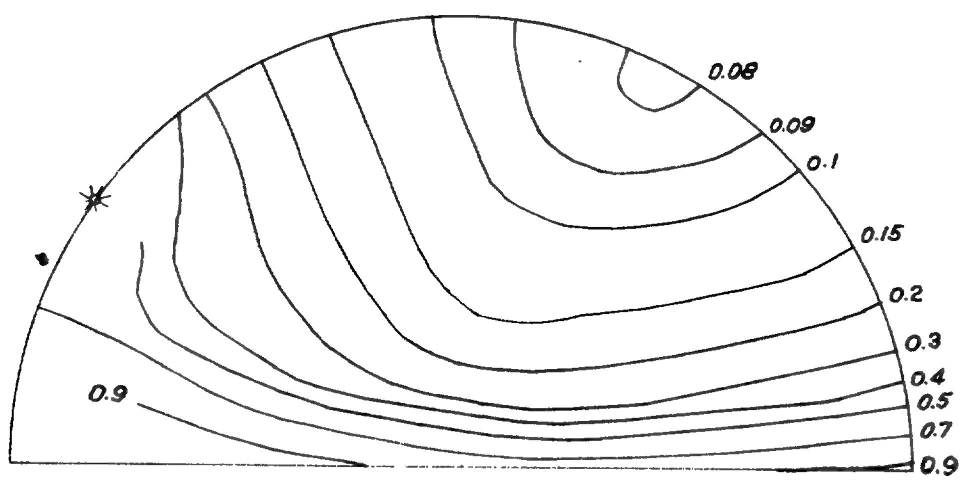


Fig. 8 - Clear daylight sky in stilbs 30 VI 1951.

$Z_{\odot} = 55°8$ $\quad p = 0.89$ $\quad$ Alma Ata

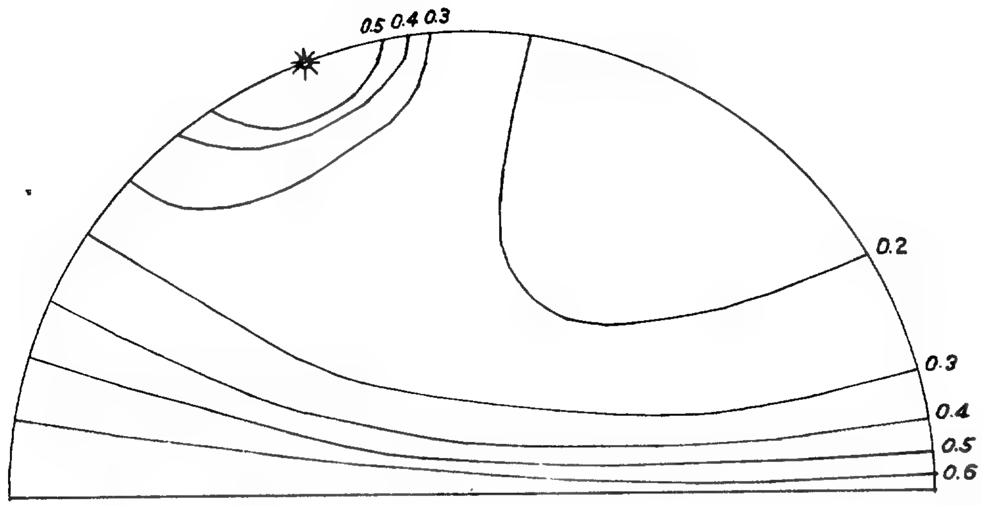


Fig. 6 - Clear daylight sky at noon in stilbs 28 VI 1951.

$z_{\odot} = 20^{\circ}.4$ p = 0.88 Alma Ata

PART C

S.F. Rodionov: Transparency of the Atmosphere in the Ultraviolet Region of the Spectrum (Izvestiya, Akademiya Nauk S.S.S.R., T. 14, Vyp. 4, Ser. Geograf. i Geofizich., 1950, p. 334.

1. Introduction, 2. Instruments

The usual procedure for determining the thickness of the ozone layer x at normal pressure and temperature involves the use of the Lambert-Bouguer formula

$$I = I_o 10^{-[\alpha x L(z) + \beta \ell(z) + \Delta \ell(z) + \gamma \ell(z)]}$$

where I is the observed monochromatic intensity at 2850Å < λ 3300Å, I_o the intensity at the same λ, outside the atmosphere, α is the ozone absorption coefficient, β that of Rayleigh scattering, Δ that of the aerosols, γ that of oxygen. The quantities L(z) and ℓ(z) are the air masses at the given zenith distance of the sun through the ozone layer and through the entire atmosphere. They are normalized such that for z = o, ℓ (z) = L(z) = 1. In practice I_λ is measured as a function of z. The slope of the curves lg I_λ gives x. In most investigations z was made small. The present paper extends the work to large zenith distances. The measurements were made during an expedition to Mt. Elbrus at elevations of up to 4250 meters.

The instrumental difficulties are great because of the weakness of the sun's radiation at 3200 - 2850Å. Two quartz monochrometers were used, one behind the other. The measuring device was a photoncounter.

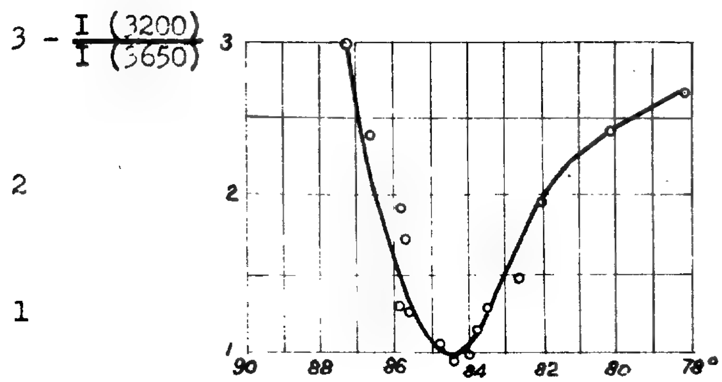
3. Results of Measurements

A large number of measurements are presented. The effect of an anomalous transparency of the atmosphere in the extreme ultraviolet region is best

shown, when log I_λ/I (3260Å) is plotted against the zenith distance of the sun. These curves show minima at about $z = 75^\circ$, which means that while the intensity in all λ's continues to decrease with increasing z, this decrease becomes less rapid for the extremely short wave lengths, $\lambda < 3260$Å. The minimum itself varies with λ, such that at $\lambda = 2950$; $\lambda = 3021$; $\lambda = 3125$ mean λ (min) is at

$$z = 75^\circ; \quad 79^\circ; \quad 83^\circ$$

The best observations made on Mt. Elbrus are shown graphically



The anomalous effect is absent in the ordinary region of the spectrum $3260 < \lambda < 6700$, where the method based upon equation (1) holds for all values of z.

4. Control Observations

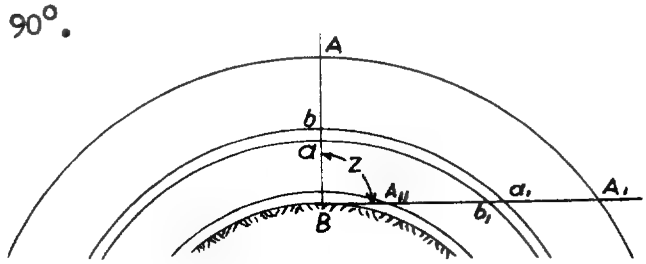
Various observations were made to make quite certain that the effect is real. Convincing evidence was secured, for example, from a study of the edge of the sun.

5. Theory

An earlier theory (1938) by Khvostikov and Yershova indicated that the ozone layer may have "holes" in it near sunset and sunrise, with a marked diminution is ozone at night. The author made special observations of the

Chappui's bands of O_3 near λ 6061, where the maximum of this band is located, and at λ 6223 near the edge of the band, and found no indication of a diminution of O_3 at sunset and sunrise (he observed the sun and did not have any data at night). He therefore discards this theory and assumes that the amount of O_3 remains constant during the day.

Rodionov next investigates the effects of layers at different altitudes. The simplest case is a comparison of two layers: one at a considerable height, due to ozone, and another hugging the surface of the earth due to aerosols. From the diagram it is clear that if $\ell(z)$ is caused by the low layer and $L(z)$ by the high layer, the ratio $L(z)/\ell(z)$ will decrease with increasing $z \rightarrow 90^{\circ}$.



It is also shown that for large z

$$\frac{dL(z)}{dz} < \frac{d\ell(z)}{dz} .$$

This elementary picture becomes more complicated in the general case, and the author derives several consecutive approximations for $L(z)$ and $\ell(z)$, making allowance for refraction and change of density with height. His final expressions are

$$\ell(z) = \frac{1}{H_o} \int_R^{\infty} \frac{\rho_h dr}{\rho_o \sqrt{1 - \left(\frac{R\mu_o}{r\mu_h}\right)^2 \sin^2 \zeta}} = f(z)$$

$$L(z) = \frac{1}{x} \int_R^{\infty} \frac{x_h dr}{\sqrt{1 - \left(\frac{R\mu_o}{r\mu_h}\right)^2 \sin^2 \zeta}} = F(z)$$

Here the angle ζ differs from z by the refraction. The other symbols are self-evident.

With the help of these expressions, curves are constructed for f(z), F(z), $\frac{df(z)}{dz}$, $\frac{dF(z)}{dz}$ (and also for the first approximations sec x and sec y). In the following discussion the term γ is omitted since oxygen is not present in the ultraviolet region.

In every approximation the effect of the lower strata becomes increasingly more important as $z \rightarrow 90^o$. If the different strata absorb according to the same law, with regard to λ, this would have no influence upon the values of ratios $\eta = I(\lambda)/I(3260\text{Å})$. But if the aersols absorb selectively this would produce a deformation of the curves of η. The author considers also the coefficient β (Rayleigh) but discards it because β is known theoretically and experimentally.

In order to have a minimum in the curve of η between $2950 < \lambda_1 < \lambda_2 = 3260$ we must satisfy the equation

$$(\alpha_2 - \alpha_1) \times \frac{dF(z_{min})}{dz} + (\beta_2 - \beta_1) \frac{df(z_{min})}{dz} + (\delta_2 - \delta_1) \frac{df(z_{min})}{dz} = 0$$

In this region of the spectrum $\alpha_2 < \alpha_1$ — we are in the long wave region of Hartley band of O_3, and also $\beta_2 < \beta_1$. Also we know that F(z) and f(z) are increasing function of z. Hence,

$$(\alpha_2 - \alpha_1) \times \frac{dF(z_{min})}{dz} < 0$$

$$(\beta_2 - \beta_1) \frac{df(z_{min})}{dz} > 0$$

Hence, the condition for the minimum requires that $(\Delta_2 - \Delta_1) \frac{df(z_{min})}{dz} > 0$ and since $df(z)/dz > 0$ this means that

$$\Delta_2 - \Delta_1 > 0$$

or

$$\Delta_2 > \Delta_1$$

It is customary to put

$$\Delta \sim \lambda^{-a}$$

Then in the region $2950 < \lambda < 3260$Å we must have $a < 0$.
In other words, in this region of the spectrum the scattering of light by the aerosols must increase with λ. This suggests that the region under investigation, 2950Å to 3260Å, represents the short-wave side of an absorption band of the aerosols. The possibility of such a band had already been suggested by Mie, Stratton and Haughton, by Shullikin, etc.

Thus the anomalous effect of UV transparency is the result of the superposition of the long-wave side of the Hartley band of O_3 and the short-wave side of the new band of the aerosols, with the gradual tendency of low-level aerosols to predominate at larger z.

The author computes

$$\Delta_2 - \Delta_1 = \frac{(\alpha_1 - \alpha_2) \; x \; \frac{dF}{dz}}{df/dz} + (\beta_1 - \beta_2)$$

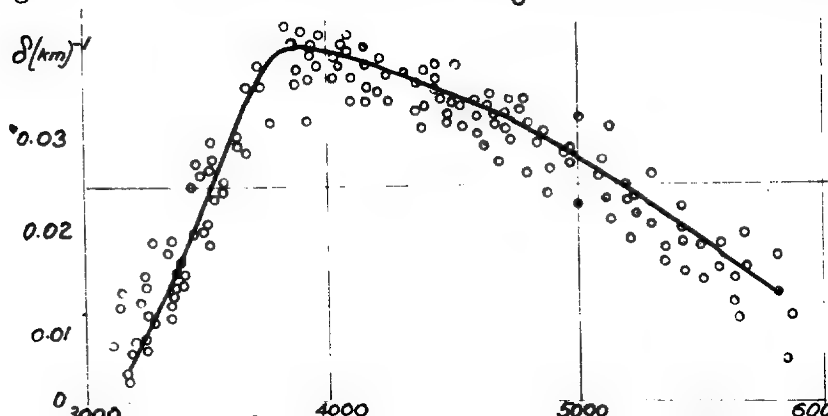
He knows the values of α, β for different wave lengths; x is known from other observations: $x = 0.25$ cm. The derivatives at z = min are given by the observations. The result is:

λ	α	β	z_{min}	$\frac{dF(z_{min})}{dz}$	$\frac{df(z_{min})}{dz}$	$\Delta_2 - \Delta_1$
3260	0.05*	0.175	—	—	--	0
3125	0.09	0.220	82°	4.4	8.6	0.154
3021	3.6	0.245	77°	2.3	3.3	0.69
2950	9.7	0.275	75°	1.8	2.7	1.7

(the values for are taken from Läuchli, Zr. f. Phys. 53, 92, 1929)

6. Selective Transmission of the Aerosols

The author observed the transmission of the lower atmosphere through a horizontal distance of 10 km by measuring the snowy surface of the western peak of Mt. Ebrus. Photographic and photoelectric methods were employed. The result gave a curve of δ where $\Delta = \delta H_o$ (δ then refers to one km) with λ



The amount of absorption δ varies from day to day. It is attributed to water drops and snow crystals.

$$\Delta_2 - \Delta_1 = (\delta_2 - \delta_1)H_h,$$

There is some uncertainty about H_h because the H_h refers to the whole layer of aerosols, while the δ refer to that layer where p_h = 500 mm, this being the mean pressure at levels of 3 to 5.5 km.

Apparently

$$H_h = H_o p_h / p_o = 5.26 \text{ km}$$

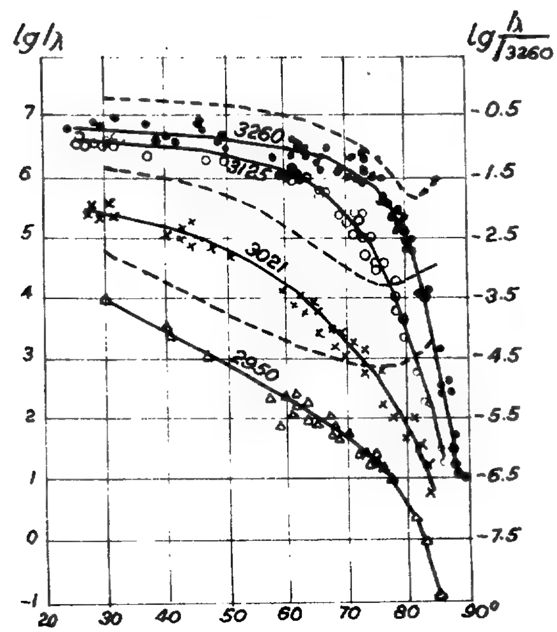
where H_o = 7.99 km = height of uniform atmosphere and p_o = 760 mm. The measures of δ then permit the author to compute $\Delta_2 - \Delta_1$. The result, for the mean of 10 days, is

$$\Delta_2 - \Delta_1 = 0.099.$$

This is close to the value $\Delta_2 - \Delta_1 = 0.116$ obtained from the measures of the UV transparency on 9 dates.

7. The Reversal Effect

Götz and Dobson found in 1934 that the light of the zenith sky shows a minimum in $\eta = I_1/I_2$ for large z. This effect was also observed by Rodionov on Mt. Elbrus. He believes that this phenomenon is closely related to the one he has dealt with in the earlier sections.



III. REPORT NO. 2

on

SOVIET INVESTIGATIONS OF THE TRANSPARENCY
OF THE EARTH'S ATMOSPHERE

[redacted] 25X1A5a1

I have recently obtained from Paris a copy of a new book on Meteorology, edited by Professor P.N. Tverskoy, and entitled, "Text-Book of Meteorology (Physics of the Atmosphere)," Hydrometeorological Printing Office, Leningrad, 1951.

This is a book of 888 pages, written by six authors: A.S. Zverev, B.V. Kiriukhin, K.Ya. Kondratiyev, E.S. Selezneva, P.N. Tverskoy, and M.I. Yudin. It is a comprehensive volume on meteorology and several of its chapters are devoted to the problem of the transparency of the earth's atmosphere.

Chapter 9, written by Professor Tverskoy, (pages 190-219) contains the following items:

1) The general absorption of radiant energy in the atmosphere.
2) The selective absorption in the atmosphere.
3) Scattering of radiant energy in the atmosphere by molecules.
4) Scattering of radiant energy by large particles.
5) Transparency of the atmosphere and its characteristics.

Chapters 39 and 40, (pages 692-750) written by the same author, treat consecutively the following items:

1) The fundamental data of photometry as applied to atmospheric optics.
2) The blue color of the sky.

3) The polarization of light scattered by the atmosphere.

4) The daily illumination by direct and scattered light.

5) The brightness, color and reflecting power of objects found in a natural landscape.

6) Twilight. Illumination of twilight.

7) The illumination at night. Illumination caused by the moon. The brightness of the night sky.

8) The distance of visibility. The principal factors which determine the distance of visibility.

9) Contrast. The contrast level of the eye.

10) Influence of the atmosphere upon the apparent brightness of an object.

11) The principal data of the theory of the distance of visibility for non-luminous objects.

12) The distance of visibility in twilight and at night. The visibility of lights.

13) Methods of determining the distance of visibility. Visual observations. Instruments for determination of visibility.

14) Methods of determining the distance of visibility of real objects.

15) Results of observations of visibility. Visibility in fog.

These chapters are based almost entirely upon the work of Soviet scientists and there are bibliographical notes at the end of each chapter. Almost no reference has been made to any of the well-known investigations by western physicists, with the exception of the work by Houghton and Stratton on the scattering of light by small particles. There is no reference to the work of Van de Hulst, and the theory is based upon investigations

by Ambarzumian, Fessenkov, and others, which were not intended primarily for the study of the terrestrial atmosphere. In this respect, the Soviet work is definitely behind the work of western scientists.

However, new methods have been developed by the Soviets and much attention is given to the development by the Academician, Shuleikin, on the scattering by particles of intermediate size and by water particles. Of particular interest are two diagrams on page 750, representing the transmission of light of different wave lengths through clouds. The principal conclusion is that infrared light has a certain advantage, though not a very large one, for relatively thin layers of fog consisting of small water droplets, but that for dense fogs with particles greater than one micron there is no advantage in the use of infrared light. Another interesting meteorological item is a diagram on page 718, prepared by V.A. Berezkin, which is intended to permit an operator to read off the visibility of objects of small angular dimensions in twilight and for different values of the contrast between the object and the background. The diagram presents a number of curves and with the help of auxiliary scales it is possible, for example, to read off that an object having a diameter of 10 minutes of arc and a contrast of 5 per cent will remain visible in twilight until the illumination has reached the value of 2 lux. This is presumably one of the many examples of the type of practical aids prepared by the Meteorological Service for the use of aviators.

I have not made an attempt to abstract completely the various chapters briefly described in the foregoing paragraphs. My general impression is that the Soviet work in this field has progressed essentially without regard to advances made in America and other western countries and that in some details

they have reached conclusions that have not been available to us. However, in a general way, there is nothing in the Soviet work that is particularly involved or outstanding.

Among recent publications in the current literature, I have abstracted a paper on the circumsolar aureole by Mrs. Piaskovskaya-Fessenkova. This work is undoubtedly very important, since it represents the first attempt to use infrared receivers in order to obtain a measurement of the scattering of sunlight approximately in the direction of the sun's rays. I am enclosing a copy of this abstract but I do not believe that at the present time it has any practical application. It simply represents a development that should be watched and that may become increasingly important from a practical point of view.

E.V. Piaskovskaya-Fessenkova: Circumsolar Aureole in Infrared Rays (Dodlady Akademiya Nauk S.S.S.R., T. 85, Vyp. 5, 1952)

The work is based upon photoelectric observations made by N.I. Ouchinnikova at the mountain observatory near Alma Ata. The effective λ_o = 9400A. A special investigation of the sulphur-silver photocell was carried out to test the stability of the instrument, with changes in the local temperature and other conditions. The actual observations of the day light glow around the sun were made at an angular distance of $\theta = 2^o$ to $2^o.5$ from the sun.

Disregarding scattering of orders higher than the first, we have

$$\mu = E/E_{\odot,m} \cdot \frac{1}{m}$$

where $\mu = f(\theta)$ is the fraction of the flux scattered into unit solid angle at θ degrees from the sun, to the incident flux; $E_{\odot,m}$ and E are the illuminations of an area held at right angles to the flux, from the sun, and from

an area in the sky of unit solid angle, located on the almucantarat of the sun, and at an angular distance θ from it; m is the air mass in the direction of the sun.

The formula applies to all λ. If $E/E_{\odot,m}$ is plotted against m, the slope of the resulting straight line gives μ.

On three days the values of μ were found to be extraordinarily different, even though in each individual day the straight line was well defined, showing that there were no conspicuous variations of μ within a single date. The results are as follows:

Date		Meteorological conditions
1951, VI/15	0.10	Warmed arctic air with considerable humidity and little dust
1951, VI/5	0.82	Tropical air with moderate humidity and moderate amount of dust
1951, VIII/22	2.40	Tropical air with little humidity and considerable amount of dust

The factor p, which is normally obtained from the slope of the Baugker straight line, in visual light, and which measures

$$E_{\odot,m} = E_{\odot,o}\, p^{m},$$

is given for only one date, VI/51, as p = 0.906. The infrared observations on the same date give p = 0.913.

A table lists the values of $B/B_{\odot}$, the ratios of the brightness of the infrared aureole in units of the average brightness of the disc of the sun, at different values of Z (and consequently at different values of the air mass, m). (Remark by the reviewer: There appears to be an error in the labeling of this table, or else in the foregoing listing of μ for the three

dates: they are inconsistent with one another.) On VIII/22, in tropical air the infrared aureole was about 28 times more brilliant than on another date when the air was of Arctic origin.

IV. TRANSPARENCY AND VISIBILITY OF THE ATMOSPHERE
(Bibliography).

I. AKADEMIYA NAUK SSSR (Academy of Sciences of the U.S.S.R.).

A. Izvestiya Akademii Nauk SSSR. Seriya Geograficheskaya i Geofizicheskaya. (Izvestiya of the Academy of Sciences of the U.S.S.R. Geography and Geophysics Series).
DLC: AS 262.A 6246 SPSU 114 Moskva
1937-1951

Rodionov, S.F., Pavlova, Ye. N., Rdultovskaya, Ye. V. and Reynov, N.M.: "Selektivnaya prozrachnost' atmosfernykh aerozoley" (Selective Transparency of Atmospheric Aerosols). IAN. Ser. Geogr. i Geofiz., 1942, No. 4, pp. 135-147. Institut teoreticheskoy geofiziki Akademii Nauk SSSR i Fizicheskiy Institut Leningradskogo Gosudarstvennogo Universiteta (Institute of Theoretical Geophysics of the Academy of Sciences of the U.S.S.R. and Physics Institute of Leningrad State University).

Izvestiya Akademii Nauk SSSR. Seriya Fizicheskaya. Moskva. (Izvestiya of the Academy of Sciences of the U.S.S.R. Physics Series).
DLC: AS 262.A 62455. SPSU 113
1936-1950

Rodionov, S.F.: "Ob izluchenii i pogloshchenii sveta v nekotorykh sloyakh atmosfery" ("Radiation and Absorption of Light in Certain Strata of the Atmosphere"). IAN, Seriya Fizicheskaya, 1950, Vol. 14, No. 3, pp. 247-256. M.F. 207-M.

Izvestiya Akademii Nauk SSSR. Seriya Geofizicheskaya. Moskva. (Izvestiya of the Academy of Sciences of the U.S.S.R. Geophysics Series).
DLC: Slavic Unclassified.

Berlyand, M. and Berlyand, T.: "Opredeleniye effektivnogo izlucheniya zemli s uchetom vliyaniya oblachnosti" ("Determination of the Effective Radiation of the Earth Taking into Account the Influence of Cloudiness"). IAN, Seriya Geofizicheskaya, 1952, No. 1, pp. 64-78. M.F. 164-K

Bezverkhniy, Sh. A., Osherovich, A.A. and Rodionov, S.F.: "Elektrofotometricheskiye issledovaniya prozrachnosti atmosfery v ul'trafioletovoy oblasti spektra" ("Electrophotometric Investigations of Transparency of the Atmosphere in the Ultra-Violet Area of the Spectrum"). IAN, Seriya Geofizicheskaya, 1952, No. 3, pp. 93-102. Geofizicheskiy Institut Akademii Nauk SSSR i Leningradskiy Gosudarstvennyy Universitet (Geophysics Institute of the Academy of Sciences of the U.S.S.R. and Leningrad State University). M.F. 201-D.

B. Astronomicheskiy Zhurnal. Moskva, Leningrad.
(Astronomy Journal).
Organ of Akademii Nauk SSSR (Organ of the Academy of Sciences of the USSR). (Title varies: 1924-1927: "Russkiy Astronomicheskiy Zhurnal").
DLC: QB 1.A 47. SPSU 416.
1924-1951.

Pyaskovskaya, Ye. V.: "Opredeleniye prozrachnosti i rasseivayushchey sposobnosti vozdukha" ("Determination of Transparency and Scattering Ability of Air"). Astr. Zhurn., 1926, No. 2, pp. 138-144.

C. Zhurnal Tekhnicheskoy Fiziki. Moskva, Leningrad.
(Journal of Technical Physics).
Organ of Akademii Nauk SSSR (Organ of the Academy of Sciences of the USSR). (Issues for 1931-1933 also called "Fizicheskiy Zhurnal. Seriya V").
DLC: QC 1.Z 48 SPSU 3342.
1931-1951.

Sharonov, V.V.: "Vizual'nyy fotometr dlya slabogo sveta" ("A Visual Photometer for Faint Light"). ZhTF, 1942, No. 12, pp. 692-693.

Sharonov, V.V.: "Primeneniye vizibilimetra k nakhozhdeniyu parametrov, opredelyayushchikh vidimost' dalekikh i blizkikh ob"yektov" ("Application of the Visibility-Meter to Determination of Parameters which Determine Visibility of Distant and Near Objects"). ZhTF, 1943, No. 13, pp. 634-691.

Veytser, Yu. I.: "O prilozhimosti nefelometricheskogo metoda k opredeleniyu dal' nosti vidimosti i Koeffitsiyenta oslableniya sveta v gustykh dymakh i tumanakh" ("Applicability of the Nephelometric Method to the Determination of Visibility and the Coefficient of Reduction of Light in Smoke and Fog"). ZhTF, 1947, Vol. 17, No. 4, pp. 469-473. Literatura (Bibliography), p. 474.

II. LENINGRADSKIY GOSUDARSTVENNYY UNIVERSITET (Leningrad State University).

A. Vestnik Leningradskogo Universiteta. Leningrad.
(Vestnik of Leningrad University).
DLC: AS 262. L 463. SPSU 1284.
1946-1950.

Sharonov, V. V.: "Raschet dal'nosti vidimosti pri zadannykh usloviyakh nablyudeniya" ("Calculation of Distance of Visibility Under Given Conditions of Observation"). VLU, No. 9, 1947, pp. 3-31. MF 205-B. Figures and Bibliography (27 items).

B. Uchenyye Zapiski Leningradskogo Universiteta. Leningrad.
(Learned Notes of Leningrad University).
DLC: Not given. SPSU 1283.
1935-1941.

Sharonov, V. V.: "Universal'nyy klinovoy fotometr" ("A Universal Wedge Photometer"). Uch. Zap. L. U., 1939, No. 31, pp. 72-81.

Sharonov, V. V.: "Izmereniye i raschet gorizontal'noy dnevnoy vidimosti" ("Measurement and Calculation of Horizontal Daytime Visibility"). Uch. Zap. L. U., 1940, No. 58, pp. 73-92.

III. INSTITUTE PUBLICATIONS.

A. Krymskiy Nauchno-issledovatel'skiy Institut. Simferopol'.
(Crimean Scientific-Research Institute).

Trudy Krymskogo Nauchno-issledovatel'skogo Instituta.
(Transactions of the Crimean Scientific-Research Institute).

Tikhanovskiy, I.I. (Prof.): "Optika Kryma" ("Optics of Crimea"). Trudy KNII, 1926, Vol. 1, No. 1, pp. 3-13. (Tables include data on transparency of air.) DLC: Q60 S5. MF 205-C.

B. Krymskiy Pedagogicheskiy Institut.
(Crimean Pedagogical Institute).

Izvestiya Krymskogo Pedagogicheskogo Instituta. Simferopol'.
(Izvestiya of the Crimean Pedagogical Institute).

Tikhanovskiy, I.I.: "Teoriya polyarizatsii i yarkosti sveta dlya absolutno chistoy zemnoy atmosfery" ("Theory of Polarization and Brightness of Light for Absolutely Pure Atmosphere of the Earth"). IKPI, 1928, Vol. 2, pp. 175-179. DLC: L53.S512. 1927-1941. MF 205-L. SPSU 2583.

Kastrov, V.G.: "Prozrachnost' absolutno chistoy i sukhoy atmosfery dlya solnechnoy radiatsii" ("Transparency of Absolutely Pure and Dry Atmsophere for Solar Radiation"). IKPI, 1928, No. 2, pp. 180-186. MF 205-L.

C. Petrogradskiy Agronomicheskiy Institut.
(Petrograd Agronomy Institute).

Zhurnal Petrogradskogo Agronomicheskogo Instituta.
(Journal of the Petrograd Agronomy Institute).

Kalitin, N.N.: "K voprosu o kolebaniyakh prozrachnosti atmosfery" ("On the Question of Fluctuations of Transparency of the Atmosphere"). ZhPAI, 1919.

Kalitin, N.N.: "Velichina i izmeneniya obshchego koeffitsiyenta prozrachnosti atmosfery" ("Magnitude and Change of the Over-all Coefficient of Transparency of the Atmosphere"). ZhPAI, 1921.

D. Sredneziatskiy Meteorologicheskiy Institut.
(Middle-Asian Meteorological Institute).

Byulleten' Sredneaziatskogo Meteorologicheskogo Instituta.
(Bulletin of the Middle-Asian Meteorological Institute).

Trofimov, K. G.: "Prozrachnost' zemnoy atmosfery v Tashkente za chetyre goda (1926-1929gg.)" ("Transparency of the Atmosphere of the Earth at Taskent for Four Years ((1926-1929))"). Byulleten' Sredneaziat. Meteor. Inst., 1930, No. 7.

E. Tsentral'nyy Nauchno-issledovatel'skiy Institut Geodezii, Aeros'yemki i Kartografii.
(Central Scientific-Research Institute of Geodesy, Aerial Survey and Cartography).

Trudy Tsentral'nogo Nauchno-issledovatel'skogo Instituta Geodezii, Aeros'yemki i Kartografii.
(Transactions of the Central Scientific-Research Institute of Geodesy, Aerial Survey and Cartography).
DLC: QB 275. M 64. SPSU 1775.
1931-1948.

Sharonov, V.V.: "Issledovaniye razlichayemostey" ("Investigation of Distinctness"). Trudy TsNIIGAiK, 1937, No. 20, pp. 40-57.

IV. GLAVNOYE UPRAVLENIYE GIDROMETEOROLOGICHESKOY SLUZHBY PRI SOVETE MINISTROV SSSR.
(Main Administration of the Hydrometeorological Service under the Council of Ministers of the USSR).

A. Glavnaya Geofizicheskaya Observatoriya.
(Main Geophysics Observatory).

1. Izvestiya Glavnoy Geofizicheskoy Observatorii. Leningrad.
(Izvestiya of the Main Geophysics Observatory).
DLC: QC 801. L 467. SPSU (None).

Batygina, A. I.: "Prozrachnost' zemnoy atmosfery dlya Slutska v 1927-1931 godakh" ("Transparency of the Atmosphere of the Earth for Slutsk in 1927-1931"). IGGO, No. 4, 1932, pp. 14-24. MF 89-P.

2. Trudy Glavnoy Geofizicheskoy Observatorii. Leningrad.
(Transactions of the Main Geophysics Observatory).
DLC: QC 801.L 46 SPSU: 1168.
1934-1950.

Batygina, A.: "Faktory mutnosti zemnoy atmosfery dlya nekotorykh punktov SSSR" ("Factors of Turbidity of the Atmosphere of the Earth for Certain Points of the USSR"). TGGO, Vol. 1, No. 1, 1934.

Boldyrev, N. G.: "Izmereniye dal'nosti vidimosti morskikh ob"yektov" ("Measurement of the Distance of Visibility of Sea Objects"). TGGO, Vol. 1 (63), No. 9, 1947.

Gavrilov, V. A.: "Novyy pribor DM-7 dlya opredeleniya dal'nosti vidimosti ob"yektov i ogney" ("A New Device, DM-7, for Determination of Distance of Visibility of Objects and Fires"). TGGO im. A. I. Voyekova, Vol. 19(81), 1950, pp. 66-78. MF 94-L.

Polyakova, Ye. A.: "Spektrograficheskoye izucheniye prozrachnosti atmosfery dlya ul'trafioletovoy radiatsii solntsa" ("Spectrographic Study of Transparency of the Atmosphere for Ultra-violet Radiation of the Sun"). TGGO imeni A. I. Voyekova, Vol. 19(81), 1950, pp. 185-192. MF 94-L.

3. Geofizicheskiy Sbornik. Leningrad.
(Geophysics Reference Book).
Izdavayemyy Glavnoy Geofizicheskoy Observatoriyey. (Issued by the Main Geophysics Observatory).

Kalitin, N. N.: "Prozrachnost zemnoy atmosfery po nablyudeniyam v Slutske" ("Transparency of the Atmosphere of the Earth According to Observations in Slutsk"). Geof. Sborn. Vol. 4, No. 2, 1925, pp. 49-73. Résumé in French, pp. 74-75. Tables, pp. 76-86. Three pages of graphs.

Batygina, A. I.: "Prozrachnost zemnoy atmosfery dlya Slutska za 21 god (1906-1926)" ("Transparency of the Atmosphere of the Earth for Slutsk for 21 Years ((1906-1926)"). Geof. Sborn., Vol. 6, No. 1, 1927.

4. Meteorologiya i Gidrologiya. Moskva, Leningrad.
(Meteorology and Hydrology).
DLC: QC 851. M 27 SPSU 1503.
1936-1946.

Danilin, A. I.: "Tumany v Moskve v zavisimosti ot sinopticheskogo polozheniya i sostoyaniya meteorologicheskikh elementov" ("Fogs in Moscow Depending on the Synoptic Position and Condition of Meteorological Elements"). Met. i Gidr., 1936, No. 2, pp. 14-29. MF 205-D.

Vorontsov, B.: "Opredeleniye dal'nosti videniya noch'yu priborom Viganda" ("Determination of Distance of Vision at Night with the Vigand Apparatus"). Met. i Gidr., 1936, No. 8, pp. 72-75. MF 166-H.

Beletskiy, F. A.: "Svyaz' mutnosti atmosfery v Odesse s vozdushnymi massami" ("Connection of Turbity of the Atmosphere in Odessa with Air Masses"). Met. i Gidr., 1937, No. 1, pp. 97-101. Tables and Bibliography. MF 205-E.

Yaroslavtsev, I.: "K voprosu o mutnosti atmosfery v Tashkente" ("On the Question of the Turbidity of the Atmosphere in Tashkent"). Met. i Gidr., 1937, No. 1, pp. 102-103. Tables and Bibliography. MF 205-E.

Sivkov, S.: "K voprosu o prozrachnosti atmosfery v Tashkente i Slutske" ("On the Question of the Transparency of the Atmosphere in Tashkent and Slutsk"). Met. i Gidr., 1937, No. 8, pp. 94-96. Table and Bibliography. MF 205-F and MF 141-D.

Piskun, V. F.: "Novyy metod opredeleniya dal'nosti vidimosti i koefitsienta ekstinktsii sveta v prizemnom sloye atmosfery" ("A New Method of Determination of Distance of Visibility and Coefficient of Extinction of Light in the Stratum of Atmosphere Next to the Earth"). Met. i Gidr., 1938, No. 4, pp. 21-32. Figures and summary in English. MF 205-G.

Piskun, V. F. (Moskovskaya Geofizicheskaya Observatoriya ((Moscow Geophysics Observatory)): "Novyy metod izmereniya vidimosti v pokhodnykh usloviyakh" ("A New Method of Measuring Visibility in Field Conditions"). Met. i Gidr., 1939, No. 7, pp. 125-133. MF 205-H.

Piskun, V. F.: "O postroyenii kharakteristik meteorologicheskikh usloviy vidimosti" "Building Up the Characteristics of Meteorological Conditions of Visibility"). Met. i Gidr., 1940, No. 9, pp. 94-100. Figures. MF 205-I.

Faas, V. A.: "Issledovaniye vidimosti v atmosfere, imeyushchey povyshennuyu mutnost'" ("Investigation of Visibility in Atmosphere Having Increased Turbidity"). Met. i Gidr., 1941, No. 6, pp. 7-12.

5. Meteorologicheskiy Vestnik.
(Meteorological Messenger).

Sharonov, V. V.: "Novyy sposob izmereniya vidimosti i zadymlennosti atmosfery" ("A New Method of Measurement of Visibility and Haze of the Atmosphere"). Met. Vestn., 1934, No. 10-12.

Sharonov, V. V.: "Novyy pribor dlya izmereniya dymki i vidimosti" ("A New Device for Measurement of Mist and Visibility"). Met. Vestn., 1934, No. 44, pp. 301-311.

6. Mirovedeniye.
Sektor Nauki Narkomprosa.
(Science Section of the People's Commissariat of Education).

Tikhov, G. A.: "Anomal'naya dispersiya sveta v zemnoy atmosfere" ("Anomalous Dispersion of Light in the Atmosphere of the Earth"). Mirovedeniye, 1935, Vol. 24, No. 6, pp. 361-372. DLC: QB 1. R 933.

V. PERIODICALS NOT ATTACHED TO A PARTICULAR INSTITUTION.

A. Klimat i Pogoda.
(Climate and Weather).

Karpov, A. N.: "Opticheskiye yavleniya v atmosfere pri razlichnykh vozdushnykh massakh" ("Optical Phenomena in the Atmosphere Near Various Air Masses"). Klimat i Pogoda, 1935, No. 3, pp. 12-14. DLC: QC 851.L 452. MF 205-C.

B. Problemy Fiziologicheskoy Optiki. Moskva, Leningrad.
(Problems of Physiological Optics).
DLC: QP 475. P 87. SPSU 2158.
1941-1948.

Veynberg, V. B.: "K voprosu o dal'nosti vidimosti predmetov" ("On the Question of Distance of Visibility of Objects"). Prob. Fiz. Opt., 1946, No. 3, pp. 50-57.

C. Zhurnal Geofiziki.
(Journal of Geophysics).

Sivkov, S. I.: "Solnechnaya radiatsiya i prozrachnost' atmosfery v Kurske" ("Solar Radiation and Transparency of the Atmosphere at Kursk"). Zhurn. Geof., 1931, No. 1-2.

Barbaumov, N. I.: "O mutnosti atmosfery v Odesse v 1931g." ("Turbidity of the Atmosphere at Odessa in 1931"). Zhurn. Geof., Vol. 4, 1934.

VI. BOOKS AND MONOGRAPHS.

Averkiyev, M. S.: "Meteorologiya" ("Meteorology"). Izdatel'stvo Moskovskogo Universiteta, Moskva, 1951. (380 pages). Glava XX (Chapter 20): Nablyudeniya nad Oblakami, Tumanami, Vidimost'yu i Zapylennost'yu (Observations on Clouds, Fogs, Visibility and Dustiness), pp. 354-358. Paragraph 172: Vidimost' (Visibility), p. 356. OSU: QC 861 . A 8. (Book now at MCRL).

Berezkin, Vl. A.: "Vidimost'. Rukovodstvo po Aktinometrii dlya Polyarnykh Stantsiy" ("Visibility. A Handbook of Actinometry for Polar Stations"). 1938.

Prik, Z. M.: "Klimaticheskiy Ocherk Karskogo Morya" ("A Climatic Survey of the Kara Sea"). Edited by Ye. I. Tikhomirov. (Trudy Arkticheskogo Nauchno-issledovatel'skogo Instituta Glavnogo Upravleniya Severnogo Morskogo Puti. Tom 187). Izdatel'stvo Glavsevmorputi, Moskva, Leningrad, 1946. Glava X (Chapter 10): Vidimost' (Visibility). DLC: G 600 . L 4. MF 140-C.

Sharonov, V. V.: "Nablyudeniye i Vidimost'" ("Observation and Visibility"). Akademiya Nauk SSSR. Nauchno-populyarnaya Seriya. (Editor: S. I. Vavilov). Izdatel'stvo AN SSSR. Moskva, Leningrad, 1943. Glava III (Chapter 3): Vidimost' v Mutnom Vozdukhe (Visibility in Turbulent Air). New York Public Library: *QCC p.v. 798 No. 3. DLC: QC 355.S 52. MF 73-A. (Also, Title Page and Table of Contents only: MF 154-V.)

Sharonov, V. V.: "Izmereniye i Raschet Vidimosti Dalekikh Predmetov" ("Measurement and Calculation of Visibility of Distant Objects"). OGIZ. Gosudarstvennoye Izdatel'stvo Tekhniko-teoreticheskoy Literatury. Moskva, Leningrad, 1947. DLC: QC 355. S 5. MF 80-A. (Introduction, Table of Contents and Bibliography only: MF 154-U).

"Tablitsy dlya Rascheta Prirodnoy Osveshchennosti i Vidimosti" ("Tables for Calculation of Natural Illumination and Visibility"). Izdatel'stvo AN SSSR, 1945, 198 pages.

Tverskiy, P. N. (Editor).: "Kurs Meteorologii" ("A Course in Meteorology"). Fizika Atmosfery (Physics of the Atmosphere). Gidrometeorologicheskoye Izdatel'stvo, Leningrad, 1951. (878 Pages). (Book now at MCRL). Glava XL (Chapter 40): Vidimost' (Visibility), pp. 733-750. Chapter XLVII (Chapter 47): Polyarnyye Siyaniya (Polar Lights). OSU: QC 861 . T 85.

"Optika v Voyennom Dele" ("Military Optics"). Edited by Academician S. I. Vavilov and Professor M. V. Sevast'yanova. 3rd. Edition. Vol. I. Izdatel'stvo Akademii Nauk SSSR. Moskva, Leningrad, 1945. Glava 9 (Chapter 9): Dal'nost' Vidimosti i Prozrachnost' Atmosfery (Distance of Visibility and Transparency of the Atmosphere). N. Ye. Rimyn', pp. 244-265. (Book at MCRL).